Appendix A

Appendix A. Total bare sandbar habitat area by year and elevation, Lower Mississippi River, RM 315 to 954, AHP. AC40, AC60, AC70, and AC80 are acres for the 1948-50, 1963-65 and 1988-89 habitat maps; AC4060P, AC6070P, AC7080P are percent changes between years.

ELE	RMILE	AC40	AC60	AC70	AC80	AC4060P	AC6070P	AC7080P
0	325	3,390	2,370	2,132	1,697	-30.09	-10.04	-20.38
	345	4,604	1,985	2,082	2,563	-56.89	4.89	23.12
	365	3,654	2,781	1,963	1,496	-23.89	-29.41	-23.81
	385	5,739	3,741	4,852	4,496	-34.81	29.70	-7.33
	405	3,385	2,879	3,758	2,178	-14.95	30.53	-42.04
	425	4,590	4,270	4,801	3,462	-6.97	12.44	-27.89
	445	2,856	1,623	1,648	1,498	-43.17	1.54	-9.10
	465	6,065	2,918	3,364	3,722	-51.89	15.28	10.64
	485	6,389	4,188	4,514	4,032	-34.45	7.78	-10.68
	505	5,412	5,401	5,788	5,226	-0.20	7.17	-9.71
	525	5,934	4,784	5,706	4,654	-19.38	19.27	-18.44
	545	5,781	5,030	5,006	4,412	-12.99	-0.48	-11.87
	565	7,755	3,609	4,523	3,604	-53.46	25.33	-20.32
	585	3,768	4,308	5,350	4,156	14.33	24.19	-22.32
	605	5,911	4,265	4,471	4,512	-27.85	4.83	0.92
	625	5,123	3,409	3,711	4,004	-33.46	8.86	7.89
	645	4,325	4,191	3,772	4,823	-3.10	-10.00	27.87
	665	3,697	2,430	4,349	5,053	-34.27	78.97	16.20
	685	5,257	2,606	4,469	4,419	-50.43	71.49	-1.12
	705	4,979	3,479	3,969	3,286	-30.13	14.08	-17.21
	725	6,136	3,099	2,928	3,721	-49.49	-5.52	27.08
	745	4,702	2,748	3,763	3,632	-41.56	36.94	-3.48
	765	7,023	2,630	3,960	4,428	-62.55	50.57	11.82
	785	6,849	4,354	2,003	3,605	-36.43	-54.00	79.97
	805	3,609	3,177	3,629	4,005	-11.97	14.23	10.36
	825	4,852	4,220	5,150	5,468	-13.03	22.04	6.17
	845	3,818	3,460	1,310	3,266	-9.38	-62.14	149.30
	865	5,793	4,188	3,099	4,244	-27.71	-26.00	36.95
	885	5,423	2,796	1,046	2,440	-48.44	-62.59	133.27
	905	2,930	2,428	2,939	2,854	-17.13	21.05	-2.89
	925	5,139	3,397	3,631	3,145	-33.90	6.89	-13.38
	945	3,186	1,896	1,815	2,584	-40.49	-4.27	42.37
	TOTAL	158,074	108,660	115,501	116,685	-31.26	6.30	1.03

Appendix A (Continued.). Total bare sandbar habitat area by year and elevation, Lower Mississippi River, RM 315 to 954, AHP. AC40, AC60, AC70, and AC80 are acres for the 1948-50, 1963-65 and 1988-89 habitat maps; AC4060P, AC6070P, and AC7080P are percent changes between years.

ELE	RMILE	AC40	AC60	AC70	AC80	AC4060P	AC6070P	AC7080P
10	325	2,415	1,276	1,392	959	-47.16	9.09	-31.08
	345	3,630	851	1,333	1,335	-76.56	56.64	0.18
	365	2,160	1,957	1,252	900	-9.40	-36.02	-28.15
	385	3,885	2,036	3,291	3,010	-47.59	61.64	-8.55
	405	2,268	1,639	2,479	965	-27.73	51.25	-61.06
	425	3,278	2,675	3,089	1,272	-18.40	15.48	-58.83
	445	1,774	790	899	406	-55.47	13.80	-54.88
	465	4,363	1,434	1,704	2,096	-67.13	18.83	22.98
	485	3,878	1,698	2,180	1,856	-56.21	28.39	-14.86
	505	3,367	2,974	3,234	3,480	-11.67	8.74	7.61
	525	3,567	2,597	2,347	2,716	-27.19	-9.63	15.71
	545	2,877	2,282	2,235	2,098	-20.68	-2.06	-6.14
	565	4,974	1,313	2,857	2,384	-73.60	117.59	-16.56
	585	2,438	2,393	3,596	2,754	-1.85	50.27	-23.41
	605	4,276	1,459	2,069	2,112	-65.88	41.81	2.10
	625	2,629	1,329	1,575	1,928	-49.45	18.51	22.41
	645	2,560	2,067	1,896	2,732	-19.26	-8.27	44.10
	665	2,186	483	1,930	3,004	-77.90	299.59	55.66
	685	3,514	957	2,741	3,041	-72.77	186.42	10.94
	705	2,724	1,083	1,247	887	-60.24	15.14	-28.89
	725	3,176	1,294	599	1,300	-59.26	-53.71	117.03
	745	2,195	945	1,484	1,773	-56.95	57.04	19.47
	765	4,503	1,187	1,440	1,477	-73.64	21.31	2.57
	785	3,850	1,727	483	1,077	-55.14	-72.03	122.94
	805	2,051	1,437	1,440	1,500	-29.94	0.21	4.19
	825	2,538	1,635	2,134	2,383	-35.58	30.52	11.67
	845	1,892	1,195	258	689	-36.84	-78.41	166.98
	865	3,839	1,044	707	1,694	-72.81	-32.28	139.58
	885	3,093	1,002	171	582	-67.60	-82.93	240.35
	905	1,738	799	974	737	-54.03	21.90	-24.33
	925	3,315	1,475	1,440	1,059	-55.51	-2.37	-26.43
	945	1,562	442	660	594	-71.70	49.32	-10.00
	TOTAL	96,515	47,475	55,136	54,799	-50.81	16.14	-0.61

Appendix A (Continued.). Total bare sandbar habitat area by year and elevation, Lower Mississippi River, RM 315 to 954, AHP. AC40, AC60, AC70, and AC80 are acres for the 1948-50, 1963-65 and 1988-89 habitat maps; AC4060P, AC6070P, AC7080P are percent changes between years.

ELE	RMILE	AC40	AC60	AC70	AC80	AC4060P	AC6070P	AC7080P
15	325	1,899	777	994	556	-59.08	27.93	-44.04
	345	3,221	416	1,013	893	-87.08	143.51	-11.85
	365	1,536	1,423	443	683	-7.36	-68.87	54.13
	385	3,053	1,366	2,213	2,322	-55.26	62.01	4.93
	405	1,604	1,074	1,321	501	-33.04	23.00	-62.04
	425	2,669	1,920	2,405	607	-28.06	25.26	-74.76
	445	1,128	476	703	258	-57.80	47.69	-63.33
	465	3,422	872	857	1,377	-74.52	-1.72	60.63
	485	2,740	882	1,451	985	-67.81	64.51	-32.12
	505	2,017	1,785	1,636	2,320	-11.50	-8.35	41.82
	525	2,326	1,783	904	1,795	-23.34	-49.30	98.58
	545	1,800	1,140	849	1,471	-36.67	-25.53	73.29
	565	3,872	606	1,081	1,623	-84.35	78.38	50.14
	585	1,797	1,446	906	2,089	-19.53	-37.34	130.57
	605	3,319	610	1,157	1,281	-81.62	89.67	10.75
	625	1,811	708	698	1,021	-60.91	-1.41	46.30
	645	1,833	1,270	1,094	1,535	-30.71	-13.86	40.29
	665	1,312	147	1,122	1,868	-88.80	663.27	66.52
	685	2,573	510	1,831	2,098	-80.18	259.02	14.58
	705	1,580	439	506	493	-72.22	15.26	-2.49
	725	1,882	438	204	604	-76.73	-53.42	196.08
	745	1,190	521	642	953	-56.22	23.22	48.44
	765	2,976	654	863	652	-78.02	31.96	-24.45
	785	2,444	925	195	225	-62.15	-78.92	15.28
	805	1,571	844	621	645	-46.28	-26.42	3.83
	825	1,583	823	1,266	1,173	-48.01	53.83	-7.35
	845	901	401	101	191	-55.49	-74.81	89.11
	865	2,689	458	316	703	-82.97	-31.00	122.47
	885	2,260	450	54	219	-80.09	-88.00	304.81
	905	1,194	369	405	203	-69.10	9.76	-49.88
	925	2,213	774	739	369	-65.02	-4.52	-50.01
	945	852	151	400	245	-82.28	164.90	-38.75
	TOTAL	67,267	26,458	28,990	31,959	-60.67	9.57	10.24

Appendix A (Continued.). Total bare sandbar habitat area by year and elevation, Lower Mississippi River, RM 315 to 954, AHP. AC40, AC60, AC70, and AC80 are acres for the 1948-50, 1963-65 and 1988-89 habitat maps; ACP4060, AC6070P, AC7080P are percent changes between years.

ELE	RMILE	AC40	AC60	AC70	AC80	AC4060P	AC6070P	AC7080P
20	325	1,354	459	634	322	-66.10	38.13	-49.24
	345	2,705	246	633	545	-90.91	157.32	-13.84
	365	914	869	242	476	-4.92	-72.15	96.86
	385	2,264	843	1,441	1,710	-62.77	70.94	18.68
	405	1,275	693	877	232	-45.65	26.55	-73.50
	425	2,092	1,187	1,672	299	-43.26	40.86	-82.14
	445	633	244	511	153	-61.45	109.43	-70.06
	465	2,210	431	556	787	-80.50	29.00	41.62
	485	1,683	214	721	330	-87.28	236.92	-54.23
	505	991	1,026	1,063	1,026	3.53	3.61	-3.52
	525	1,392	1,036	408	1,076	-25.57	-60.62	163.77
	545	852	458	309	957	-46.24	-32.53	209.64
	565	2,774	204	546	790	-92.65	167.65	44.69
	585	1,353	757	329	1,143	-44.05	-56.54	247.42
	605	2,605	196	617	736	-92.48	214.80	19.25
	625	1,256	301	275	512	-76.04	-8.64	86.11
	645	975	713	649	722	-26.87	-8.98	11.31
	665	691	61	604	1,067	-91.17	890.16	76.69
	685	1,599	182	1,089	1,384	-88.62	498.35	27.09
	705	791	104	142	255	-86.85	36.54	79.44
	725	963	77	109	251	-92.00	41.56	130.28
	745	630	189	186	488	-70.00	-1.59	162.37
	765	1,291	261	397	392	-79.78	52.11	-1.26
	785	1,311	274	98	80	-79.10	-64.23	-17.96
	805	1,166	315	285	205	-72.98	-9.52	-27.93
	825	938	327	603	502	-65.14	84.40	-16.75
	845	208	109	47	50	-47.60	-56.88	5.96
	865	1,348	159	103	231	-88.20	-35.22	124.47
	885	1,443	200	37	70	-86.14	-81.50	88.11
	905	664	94	197	105	-85.84	109.57	-46.70
	925	1,167	191	303	133	-83.63	58.64	-55.97
	945	324	24	158	78	-92.59	558.33	-50.63
	TOTAL	41,862	12,444	15,841	17,109	-70.27	27.30	8.00

Appendix A (Continued.). Total bare sandbar habitat area by year and elevation, Lower Mississippi River RM 315 to 954, AHP. AC40, AC60, AC70, and AC80 are acres for the 1948-50, 1963-65 and 1988-89 habitat maps; AC4060P, AC6070P, AC7080P are percent changes between years.

ELE	RMILE	AC40	AC60	AC70	AC80	AC4060P	AC6070P	AC7080P
25	325	934	168	388	144	-82.01	130.95	-62.84
	345	2,298	63	246	262	-97.26	290.48	6.34
	365	349	392	167	243	12.32	-57.40	45.75
	385	1,622	308	772	1,056	-81.01	150.65	36.84
	405	887	317	453	102	-64.26	42.90	-77.40
	425	1,175	496	1,161	149	-57.79	134.07	-87.13
	445	409	97	346	80	-76.28	256.70	-76.99
	465	812	32	345	307	-96.06	978.13	-11.01
	485	942	10	501	128	-98.94	4910.0	-74.45
	505	485	340	652	356	-29.90	91.76	-45.40
	525	612	458	143	527	-25.16	-68.78	268.25
	545	241	122	107	588	-49.38	-12.30	449.91
	565	1,699	44	287	148	-97.41	552.27	-48.43
	585	884	360	123	198	-59.28	-65.83	60.98
	605	1,911	69	367	440	-96.39	431.88	19.95
	625	760	120	136	226	-84.21	13.33	66.47
	645	464	311	330	384	-32.97	6.11	16.24
	665	232	37	336	656	-84.05	808.11	95.24
	685	923	70	468	800	-92.42	568.57	70.94
	705	356	13	50	131	-96.35	284.62	161.20
	725	504	24	21	162	-95.24	-12.50	671.43
	745	311	80	52	171	-74.28	-35.00	228.85
	765	394	45	103	220	-88.58	128.89	113.59
	785	450	97	43	59	-78.44	-55.67	37.21
	805	661	140	133	93	-78.82	-5.00	-30.23
	825	248	111	240	208	-55.24	116.22	-13.33
	845	28	47	7	13	67.86	-85.11	91.43
	865	354	23	34	92	-93.50	47.83	170.59
	885	605	100	22	20	-83.47	-78.00	-8.18
	905	303	18	118	63	-94.06	555.56	-46.61
	925	424	78	128	72	-81.60	64.10	-43.59
	945	123	18	72	20	-85.37	300.00	-72.22
TOTAL		22,400	4,608	8,351	8,119	-79.43	81.23	-2.77

Appendix B

Appendix B-1. SANDBAR HABITAT AREA ABOVE THE LOW WATER REFERENCE PLANE, 1948-1950 GEOMORPHIC HABITAT MAP, LOWER MISSISSIPPI RIVER

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
5	19	100.0	0	0	0	0	0	0	0	0	0	0	19	100.0
25	82	100.0	0	0	0	0	0	0	0	0	0	0	82	100.0
45	67	100.0	0	0	0	0	0	0	0	0	0	0	67	100.0
65	51	89.5	6	10.5	0	0	0	0	0	0	0	0	57	100.0
85	37	100.0	0	0	0	0	0	0	0	0	0	0	37	100.0
105	31	100.0	0	0	0	0	0	0	0	0	0	0	31	100.0
125	268	100.0	0	0	0	0	0	0	0	0	0	0	268	100.0
145	97	100.0	0	0	0	0	0	0	0	0	0	0	97	100.0
165	67	81.7	0	0	15	18.3	0	0	0	0	0	0	82	100.0
185	132	76.7	0	0	40	23.3	0	0	0	0	0	0	172	100.0
205	196	61.6	0	0	122	38.4	0	0	0	0	0	0	318	100.0
225	533	100.0	0	0	0	0	0	0	0	0	0	0	533	100.0
245	863	76.7	12	1.1	250	22.2	0	0	0	0	0	0	1,125	100.0
265	1,195	71.4	222	13.3	256	15.3	0	0	0	0	0	0	1,673	100.0
285	2,003	99.4	0	0	12	0.6	0	0	0	0	0	0	2,015	100.0
305	1,911	78.6	107	4.4	413	17.0	0	0	0	0	0	0	2,431	100.0
325	2,882	85.0	0	0	508	15.0	0	0	0	0	0	0	3,390	100.0
345	3,364	73.1	1,034	22.5	206	4.5	0	0	0	0	0	0	4,604	100.0
365	1,650	45.2	892	24.4	1,112	30.4	0	0	0	0	0	0	3,654	100.0
385	3,897	67.9	1,135	19.8	707	12.3	0	0	0	0	0	0	5,739	100.0
405	2,418	71.4	0	0	967	28.6	0	0	0	0	0	0	3,385	100.0
425	2,901	63.2	1,684	36.7	5	0.1	0	0	0	0	0	0	4,590	100.0
445	2,081	72.9	605	21.2	170	6.0	0	0	0	0	0	0	2,856	100.0
465	4,272	70.4	759	12.5	1,034	17.0	0	0	0	0	0	0	6,065	100.0
485	3,131	49.0	3,030	47.4	228	3.6	0	0	0	0	0	0	6,389	100.0
505	2,685	49.6	761	14.1	1,966	36.3	0	0	0	0	0	0	5,412	100.0
525	3,254	54.8	1,395	23.5	1,285	21.7	0	0	0	0	0	0	5,934	100.0
545	3,207	55.5	800	13.8	1,774	30.7	0	0	0	0	0	0	5,781	100.0
565	4,931	63.6	0	0	2,824	36.4	0	0	0	0	0	0	7,755	100.0
585	3,517	93.3	0	0	251	6.7	0	0	0	0	0	0	3,768	100.0
605	5,494	92.9	0	0	417	7.1	0	0	0	0	0	0	5,911	100.0

(CONTINUED)

(Appendix B1, CONTINUED)

20-MI.	SANDBAR HABITAT CLASS													
	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
625	3,213	62.7	101	2.0	1,809	35.3	0	0	0	0	0	0	5,123	100.0
645	3,210	74.2	0	0	967	22.4	148	3.4	0	0	0	0	4,325	100.0
665	2,833	76.6	329	8.9	535	14.5	0	0	0	0	0	0	3,697	100.0
685	5,148	97.9	0	0	109	2.1	0	0	0	0	0	0	5,257	100.0
705	2,297	46.1	707	14.2	648	13.0	1,315	26.4	12	0.2	0	0	4,979	100.0
725	1,926	31.4	738	12.0	3,426	55.8	0	0	0	0	46	0.7	6,136	100.0
745	2,124	45.2	1,012	21.5	1,090	23.2	312	6.6	0	0	164	3.5	4,702	100.0
765	2,304	32.8	3,352	47.7	188	2.7	0	0	124	1.8	1,055	15.0	7,023	100.0
785	3,261	47.6	0	0	2,415	35.3	923	13.5	0	0	250	3.7	6,849	100.0
805	2,967	82.2	266	7.4	0	0	0	0	22	0.6	354	9.8	3,609	100.0
825	3,019	62.2	287	5.9	0	0	1,475	30.4	71	1.5	0	0	4,852	100.0
845	2,242	58.7	358	9.4	168	4.4	0	0	41	1.1	1,009	26.4	3,818	100.0
865	4,225	72.9	1,130	19.5	397	6.9	0	0	41	0.7	0	0	5,793	100.0
885	3,789	69.9	484	8.9	630	11.6	0	0	520	9.6	0	0	5,423	100.0
905	2,404	82.0	338	11.5	0	0	0	0	0	0	188	6.4	2,930	100.0
925	3,364	65.5	288	5.6	588	11.4	733	14.3	31	0.6	135	2.6	5,139	100.0
945	1,727	54.2	1,339	42.0	120	3.8	0	0	0	0	0	0	3,186	100.0
TOTAL	107,289	64.2	23,171	13.9	27,652	16.6	4,906	2.9	862	0.5	3,201	1.9	167,081	100.0

NOTE: MC = MAIN CHANNEL SANDBAR; DMC = DIKED MAIN CHANNEL SANDBAR
TSC = TEMPORARY SECONDARY CHANNEL SANDBAR; DTSC=DIKED TEMPORARY SECONDARY CHANNEL SANDBAR
PSC = PERMENANT SECONDARY CHANNEL SANDBAR; DPSC=DIKED PERMENANT SECONDARY CHANNEL SANDBAR

Appendix B-2. SANDBAR HABITAT AREA ABOVE THE LOW WATER REFERENCE PLANE, 1963-1965 GEOMORPHIC HABITAT MAP, LOWER MISSISSIPPI RIVER

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
25	46	100.0	0	0	0	0	0	0	0	0	0	0	46	100.0
45	56	100.0	0	0	0	0	0	0	0	0	0	0	56	100.0
65	117	100.0	0	0	0	0	0	0	0	0	0	0	117	100.0
85	63	100.0	0	0	0	0	0	0	0	0	0	0	63	100.0
105	8	100.0	0	0	0	0	0	0	0	0	0	0	8	100.0
125	177	83.1	36	16.9	0	0	0	0	0	0	0	0	213	100.0
145	105	100.0	0	0	0	0	0	0	0	0	0	0	105	100.0
165	31	100.0	0	0	0	0	0	0	0	0	0	0	31	100.0
185	302	100.0	0	0	0	0	0	0	0	0	0	0	302	100.0
205	325	79.1	0	0	86	20.9	0	0	0	0	0	0	411	100.0
225	681	95.5	32	4.5	0	0	0	0	0	0	0	0	713	100.0
245	914	78.4	78	6.7	174	14.9	0	0	0	0	0	0	1,166	100.0
265	499	41.8	363	30.4	331	27.7	0	0	0	0	0	0	1,193	100.0
285	1,685	78.5	389	18.1	72	3.4	0	0	0	0	0	0	2,146	100.0
305	1,344	71.3	272	14.4	270	14.3	0	0	0	0	0	0	1,886	100.0
325	1,848	78.0	522	22.0	0	0	0	0	0	0	0	0	2,370	100.0
345	1,928	97.1	57	2.9	0	0	0	0	0	0	0	0	1,985	100.0
365	1,788	64.3	981	35.3	12	0.4	0	0	0	0	0	0	2,781	100.0
385	2,383	63.7	0	0	657	17.6	17	0.5	231	6.2	453	12.1	3,741	100.0
405	1,906	66.2	420	14.6	553	19.2	0	0	0	0	0	0	2,879	100.0
425	2,680	62.8	582	13.6	728	17.0	68	1.6	0	0	212	5.0	4,270	100.0
445	1,528	94.1	0	0	95	5.9	0	0	0	0	0	0	1,623	100.0
465	2,072	71.0	166	5.7	680	23.3	0	0	0	0	0	0	2,918	100.0
485	2,307	55.1	485	11.6	851	20.3	0	0	0	0	545	13.0	4,188	100.0
505	3,032	56.1	2,369	43.9	0	0	0	0	0	0	0	0	5,401	100.0
525	1,805	37.7	168	3.5	2,387	49.9	43	0.9	381	8.0	0	0	4,784	100.0
545	1,773	35.2	1,640	32.6	297	5.9	0	0	0	0	1,320	26.2	5,030	100.0
565	1,401	38.8	1,415	39.2	793	22.0	0	0	0	0	0	0	3,609	100.0
585	2,388	55.4	1,106	25.7	814	18.9	0	0	0	0	0	0	4,308	100.0
605	2,367	55.5	1,148	26.9	122	2.9	0	0	628	14.7	0	0	4,265	100.0

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(Appendix B-2 CONTINUED)

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
625	1,558	45.7	493	14.5	590	17.3	60	1.8	0	0	708	20.8	3,409	100.0
645	2,497	59.6	0	0	171	4.1	15	0.4	1,508	36.0	0	0	4,191	100.0
665	1,304	53.7	217	8.9	909	37.4	0	0	0	0	0	0	2,430	100.0
685	1,779	68.3	574	22.0	253	9.7	0	0	0	0	0	0	2,606	100.0
705	1,782	51.2	148	4.3	802	23.1	0	0	747	21.5	0	0	3,479	100.0
725	1,551	50.0	722	23.3	0	0	0	0	826	26.7	0	0	3,099	100.0
745	834	30.3	339	12.3	0	0	244	8.9	323	11.8	1,008	36.7	2,748	100.0
765	1,646	62.6	506	19.2	357	13.6	0	0	121	4.6	0	0	2,630	100.0
785	1,413	32.5	1,133	26.0	1,184	27.2	0	0	342	7.9	282	6.5	4,354	100.0
805	2,223	70.0	312	9.8	76	2.4	0	0	0	0	566	17.8	3,177	100.0
825	1,906	45.2	0	0	297	7.0	95	2.3	1,922	45.5	0	0	4,220	100.0
845	1,870	54.0	243	7.0	157	4.5	371	10.7	0	0	819	23.7	3,460	100.0
865	2,078	49.6	589	14.1	1,082	25.8	15	0.4	424	10.1	0	0	4,188	100.0
885	2,436	87.1	0	0	360	12.9	0	0	0	0	0	0	2,796	100.0
905	1,980	81.5	0	0	448	18.5	0	0	0	0	0	0	2,428	100.0
925	2,109	62.1	260	7.7	1,028	30.3	0	0	0	0	0	0	3,397	100.0
945	1,220	64.3	233	12.3	183	9.7	99	5.2	0	0	161	8.5	1,896	100.0
TOTAL	67,745	57.8	17,998	15.4	16,819	14.4	1,027	0.9	7,453	6.4	6,074	5.2	117,116	100.0

NOTE: MC = MAIN CHANNEL SANDBAR; DMC = DIKED MAIN CHANNEL SANDBAR
TSC = TEMPORARY SECONDARY CHANNEL SANDBAR; DTSC=DIKED TEMPORARY SECONDARY CHANNEL SANDBAR
PSC = PERMENANT SECONDARY CHANNEL SANDBAR; DPSC=DIKED PERMENANT SECONDARY CHANNEL SANDBAR

Appendix B-3. SANDBAR HABITAT AREA ABOVE THE LOW WATER REFERENCE PLANE, 1974-75 GEOMORPHIC HABITAT MAP, LOWER MISSISSIPPI RIVER

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
25	194	100.0	0	0	0	0	0	0	0	0	0	0	194	100.0
45	83	100.0	0	0	0	0	0	0	0	0	0	0	83	100.0
65	78	100.0	0	0	0	0	0	0	0	0	0	0	78	100.0
85	96	100.0	0	0	0	0	0	0	0	0	0	0	96	100.0
105	161	100.0	0	0	0	0	0	0	0	0	0	0	161	100.0
125	152	81.7	34	18.3	0	0	0	0	0	0	0	0	186	100.0
145	188	100.0	0	0	0	0	0	0	0	0	0	0	188	100.0
165	67	100.0	0	0	0	0	0	0	0	0	0	0	67	100.0
185	184	100.0	0	0	0	0	0	0	0	0	0	0	184	100.0
205	211	60.1	0	0	140	39.9	0	0	0	0	0	0	351	100.0
225	516	91.5	48	8.5	0	0	0	0	0	0	0	0	564	100.0
245	738	82.5	0	0	157	17.5	0	0	0	0	0	0	895	100.0
265	579	55.7	0	0	460	44.3	0	0	0	0	0	0	1,039	100.0
285	1,419	77.0	347	18.8	76	4.1	0	0	0	0	0	0	1,842	100.0
305	1,476	65.1	142	6.3	650	28.7	0	0	0	0	0	0	2,268	100.0
325	1,332	62.5	492	23.1	308	14.4	0	0	0	0	0	0	2,132	100.0
345	1,534	73.7	548	26.3	0	0	0	0	0	0	0	0	2,082	100.0
365	1,272	64.8	516	26.3	151	7.7	24	1.2	0	0	0	0	1,963	100.0
385	2,689	55.4	207	4.3	615	12.7	853	17.6	144	3.0	344	7.1	4,852	100.0
405	2,326	61.9	0	0	0	0	1,212	32.3	216	5.7	4	0.1	3,758	100.0
425	3,404	70.9	0	0	368	7.7	889	18.5	140	2.9	0	0	4,801	100.0
445	1,371	83.2	68	4.1	209	12.7	0	0	0	0	0	0	1,648	100.0
465	1,899	56.5	686	20.4	751	22.3	0	0	28	0.8	0	0	3,364	100.0
485	2,332	51.7	0	0	0	0	939	20.8	684	15.2	559	12.4	4,514	100.0
505	2,658	45.9	500	8.6	0	0	2,167	37.4	463	8.0	0	0	5,788	00.0
525	1,564	27.4	0	0	669	11.7	3,009	52.7	352	6.2	112	2.0	5,706	100.0
545	1,392	27.8	0	0	573	11.4	1,603	32.0	1,310	26.2	128	2.6	5,006	100.0
565	1,573	34.8	258	5.7	48	1.1	2,373	52.5	271	6.0	0	0	4,523	100.0
585	2,315	43.3	316	5.9	0	0	2,404	44.9	315	5.9	0	0	5,350	100.0
605	1,751	39.2	301	6.7	288	6.4	1,875	41.9	256	5.7	0	0	4,471	100.0

(CONTINUED)

(Appendix B-3 CONTINUED)

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
625	1,507	40.6	297	8.0	96	2.6	1,462	39.4	349	9.4	0	0	3,711	100.0
645	1,416	37.5	0	0	124	3.3	1,663	44.1	320	8.5	249	6.6	3,772	100.0
665	2,154	49.5	0	0	371	8.5	1,578	36.3	246	5.7	0	0	4,349	100.0
685	2,229	49.9	452	10.1	161	3.6	1,053	23.6	574	12.8	0	0	4,469	100.0
705	1,629	41.0	0	0	488	12.3	1,093	27.5	759	19.1	0	0	3,969	100.0
725	778	26.6	106	3.6	0	0	1,545	52.8	499	17.0	0	0	2,928	100.0
745	553	14.7	0	0	0	0	2,052	54.5	1,158	30.8	0	0	3,763	100.0
765	1,715	43.3	114	2.9	953	24.1	341	8.6	315	8.0	522	13.2	3,960	100.0
785	834	41.6	170	8.5	0	0	611	30.5	179	8.9	209	10.4	2,003	100.0
805	1,323	36.5	0	0	267	7.4	1,266	34.9	773	21.3	0	0	3,629	100.0
825	1,822	35.4	0	0	0	0	2,896	56.2	432	8.4	0	0	5,150	100.0
845	270	20.6	290	22.1	88	6.7	429	32.7	233	17.8	0	0	1,310	100.0
865	1,436	46.3	326	10.5	0	0	646	20.8	613	19.8	78	2.5	3,099	100.0
885	767	73.3	112	10.7	129	12.3	2	0.2	36	3.4	0	0	1,046	100.0
905	1,637	55.7	292	9.9	616	21.0	0	0	394	13.4	0	0	2,939	100.0
925	1,973	54.3	810	22.3	848	23.4	0	0	0	0	0	0	3,631	100.0
945	547	30.1	0	0	182	10.0	22	1.2	885	48.8	179	9.9	1,815	100.0
TOTAL	58,144	47.0	7,432	6.0	9,786	7.9	34,007	27.5	11,944	9.7	2,384	1.9	123,697	100.0

NOTE: MC = MAIN CHANNEL SANDBAR; DMC = DIKED MAIN CHANNEL SANDBAR
TSC = TEMPORARY SECONDARY CHANNEL SANDBAR; DTSC=DIKED TEMPORARY SECONDARY CHANNEL SANDBAR
PSC = PERMENANT SECONDARY CHANNEL SANDBAR; DPSC=DIKED PERMENANT SECONDARY CHANNEL SANDBAR

Appendix B-4. SANDBAR HABITAT AREA ABOVE THE LOW WATER REFERENCE PLANE, 1988-89 GEOMORPHIC HABITAT MAP, LOWER MISSISSIPPI RIVER

	SANDBAR HABITAT CLASS															
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
25	51	100.0	0	0	0	0	0	0	0	0	0	0	51	100.0
45	14	100.0	0	0	0	0	0	0	0	0	0	0	14	100.0
65	18	100.0	0	0	0	0	0	0	0	0	0	0	18	100.0
85	17	100.0	0	0	0	0	0	0	0	0	0	0	17	100.0
105	24	100.0	0	0	0	0	0	0	0	0	0	0	24	100.0
125	118	100.0	0	0	0	0	0	0	0	0	0	0	118	100.0
145	140	100.0	0	0	0	0	0	0	0	0	0	0	140	100.0
165	34	100.0	0	0	0	0	0	0	0	0	0	0	34	100.0
185	167	100.0	0	0	0	0	0	0	0	0	0	0	167	100.0
205	117	78.0	33	22.0	0	0	0	0	0	0	0	0	150	100.0
225	226	88.3	0	0	30	11.7	0	0	0	0	0	0	256	100.0
245	175	94.6	10	5.4	0	0	0	0	0	0	0	0	185	100.0
265	192	61.9	118	38.1	0	0	0	0	0	0	0	0	310	100.0
285	587	88.0	0	0	80	12.0	0	0	0	0	0	0	667	100.0
305	499	80.0	61	9.8	64	10.3	0	0	0	0	0	0	624	100.0
325	977	57.5	276	16.3	0	0	43	2.6	401	23.6	0	0	1,697	100.0
345	1,152	44.9	122	4.8	247	9.6	61	2.4	929	36.2	51	2.0	2,563	100.0
365	998	66.7	0	0	0	0	140	9.4	358	23.9	0	0	1,496	100.0
385	1,807	40.2	0	0	0	0	450	10.0	826	18.4	1,414	31.4	4,496	100.0
405	822	37.7	47	2.1	0	0	152	7.0	966	44.3	192	8.8	2,178	100.0
425	1,720	49.7	285	8.2	539	15.6	160	4.6	758	21.9	0	0	3,462	100.0
445	1,080	72.1	0	0	0	0	278	18.6	140	9.4	0	0	1,498	100.0
465	2,044	54.9	277	7.4	0	0	140	3.8	1,261	33.9	0	0	3,722	100.0
485	1,460	36.2	0	0	0	0	913	22.6	647	16.0	1,012	25.1	4,032	100.0
505	2,298	44.0	0	0	0	0	553	10.6	2,375	45.4	0	0	5,226	100.0
525	1,208	26.0	0	0	0	0	564	12.1	2,001	43.0	881	18.9	4,654	100.0
545	1,780	40.4	0	0	0	0	1,073	24.3	1,211	27.5	347	7.9	4,412	100.0
565	1,261	35.0	0	0	0	0	245	6.8	2,098	58.2	0	0	3,604	100.0
585	1,707	41.1	0	0	0	0	391	9.4	2,058	49.5	0	0	4,156	100.0
605	2,034	45.1	0	0	0	0	657	14.6	603	13.4	1,217	27.0	4,512	100.0

(CONTINUED)

(Appendix B-4 CONTINUED)

	SANDBAR HABITAT CLASS													
20-MI.	MC		TSC		PSC		DTSC		DMC		DPSC		TOTAL	
REACH	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
625	1,790	44.7	0	0	0	0	531	13.3	1,556	38.9	126	3.1	4,004	100.0
645	1,912	39.6	0	0	0	0	486	10.1	2,119	43.9	307	6.4	4,823	100.0
665	2,383	47.2	0	0	240	4.8	969	19.2	1,313	26.0	147	2.9	5,053	100.0
685	2,186	49.5	0	0	397	9.0	901	20.4	935	21.2	0	0	4,419	100.0
705	1,040	31.7	0	0	6	0.2	817	24.9	1,125	34.2	298	9.1	3,286	100.0
725	1,045	28.1	0	0	104	2.8	425	11.4	418	11.2	1,729	46.5	3,721	100.0
745	626	17.2	0	0	0	0	976	26.9	2,030	55.9	0	0	3,632	100.0
765	1,721	38.9	372	8.4	843	19.0	223	5.0	1,269	28.7	0	0	4,428	100.0
785	1,052	29.2	316	8.8	27	0.7	1,210	33.6	674	18.7	327	9.1	3,605	100.0
805	1,483	37.0	0	0	0	0	1,431	35.7	415	10.4	676	16.9	4,005	100.0
825	1,668	30.5	50	0.9	0	0	492	9.0	1,860	34.0	1,398	25.6	5,468	100.0
845	718	22.0	74	2.3	293	9.0	844	25.8	760	23.3	577	17.7	3,266	100.0
865	2,372	55.9	0	0	236	5.6	1,635	38.5	0	0	0	0	4,244	100.0
885	965	39.5	107	4.4	137	5.6	325	13.3	250	10.2	656	26.9	2,440	100.0
905	1,478	51.8	287	10.1	298	10.4	287	10.1	504	17.7	0	0	2,854	100.0
925	1,536	48.8	981	31.2	582	18.5	46	1.5	0	0	0	0	3,145	100.0
945	898	34.8	84	3.3	305	11.8	692	26.8	605	23.4	0	0	2,584	100.0
TOTAL	49,600	41.5	3,500	2.9	4,429	3.7	18,110	15.2	32,466	27.2	11,355	9.5	119,460	100.0

NOTE: MC = MAIN CHANNEL SANDBAR; DMC = DIKED MAIN CHANNEL SANDBAR
TSC = TEMPORARY SECONDARY CHANNEL SANDBAR; DTSC=DIKED TEMPORARY SECONDARY CHANNEL SANDBAR
PSC = PERMENANT SECONDARY CHANNEL SANDBAR; DPSC=DIKED PERMENANT SECONDARY CHANNEL SANDBAR

Appendix C

TIME SERIES OF SANDBAR VEGETATION MAPS, CRACRAFT-CAROLINA, CHOCTAW BAR, NEBRASKA POINT, HOTCHKISS BEND-ISLAND NO. 9, AND PRITCHARD-ISLAND NO. 1 REACHES, LOWER MISSISSIPPI RIVER

Temporal trends in the spatial distribution and species composition of woody vegetation on sandbars were investigated at five sites along the LMR (Table C1). Total vegetation coverage was quantified from a time series of 1:10,000 scale black and white aerial photographs. Photographs were geo-referenced and the area of total vegetation, bare sand, and water were delineated and digitized. In addition, for the Cracraft Bar and Choctaw Bar, sandbar vegetation types were classified (Roth, 1996). Spatial data were used only for years when all vegetation was considered to be above the water level. Also, because river stage varied several feet among the years aerial photographs were collected, data on sandbar and water areas could not be compared for all years.

Cracraft-Carolina Reach

This is a relatively straight reach beginning with the Leota point bar (RM 515) and extending downriver of the Cracraft middle bar to RM 507 (Fig. 22). Lower Cracraft dike system was built in 1972 on the right bank to reduce discharge in the secondary channel and to constrict and deepen the navigation channel. Leota dike system was constructed in 1968 on the left-bank point bar to restrict development of a point bar cutoff and deepen the adjacent navigation channel.

Cracraft Bar, a large mid-channel bar on the right bank, and Leota point bar on the left bank are the major sandbars in this straight reach. The least tern utilizes Cracraft Bar as a colony site, but not Leota. No woody vegetation was evident on either sandbar in 1962 and only a few small, scattered patches were present in 1974 (Fig. C2 and Figs. C10-C13). By 1982, however, most of the downstream portion and crest of Leota sandbar was covered by willows. These conditions remained from 1982 through 1991, during which time sandbar size was stable. Woody vegetation was present along the centerline of Cracraft Bar in 1978, with spatial coverage about doubling by 1991; vegetation coverage expanded northward along the crest of the sandbar between 1991 and 1994. Cracraft Bar grew in height and expanded laterally on the main channel side. Bare sandbar area generally increased over the period of record. In 1994, black willow comprised over 90% of the vegetation cover on Cracraft Bar (Fig. C3).

Choctaw Bar Reach

This reach extends from RM 555-566 and consists of a bendway with a large point bar and island. Flow is divided with a secondary channel on the right bank and the main channel on the left bank. A stone dike system was constructed at the upstream entrance to the secondary channel in 1968 to reduce divided flow conditions and deepen the navigation channel. During the 1973 flood, a large section of the main closure dike degraded, creating a weir, which allows significant flow in the secondary channel.

Choctaw Bar Island has been present since the 1930's, although it has shifted in size and location through the years. Sedimentation has resulted in lateral, upstream and downstream growth of the point bar, especially following the 1973 flood (Figs. C14-C18). About 675 acres of woody vegetation were present in bands along the center and borders of Choctaw Bar in 1962 (the first available aerial photography) (Fig. C4). By 1967, the amount of woody vegetation in the reach had approximately doubled to over 1,300 acres, mainly due to expansion on Choctaw Bar and colonization of two smaller sandbars. In 1974, woody vegetation had decreased by about 50%, partly due to destruction of vegetation stands on Choctaw Bar by the 1973 flood. It took only to years, however, for the

vegetation to return to pre-flood amounts. Following the flood of 1973, woody vegetation spread on both ends of Choctaw Bar and the sandbars contiguous to the right bank, but it took only two years for vegetated area to return pre-1973 flood amounts. Woody vegetation increased within the reach to 1,800 acres in 1987, then declined to 1,410 acres in 1988 and to about 1,867 acres in 1991. By 1994, vegetated area had declined to 1,407 acres. Black willow made up approximately 69% of the woody vegetation in 1994, with scrub/shrub (young willows) comprising the remainder. Despite the relatively old age of Choctaw Bar, fluvial and hydrologic processes have not allowed succession to advance beyond the willow sere. Sedimentation and aggradation have not resulted in elevations >LWRP74+20 and scour by floods have set back plant succession. Significant amounts of sandbar have remained non-vegetated.

The amount of bare sandbar was relatively stable over the period of record, although spatial distribution varied. Total area was 3,232 ac in 1964, 3,331 ac in 1988 and 2,992 ac in 1991. River stage was 1-2 ft above LWRP74 when aerial photography was obtained for these years.

Nebraska Point-Barfield Bend Reach

Located between RM 806-813, this reach is comprised of a long-radius bendway and associated blunt-nose point bar. Below Tamm Bend dike system (RM 812-814) was constructed in 1967 to deepen the navigation channel at the upstream end of the reach, and Nebraska Point dike system (RM 806-809) was built in 1979 to constrict and deepen the navigation channel at the downstream end of the reach, and to degrade a large mid-channel bar and eliminate divided flow.

A large section of the point bar at Nebraska Point has consistently been forested over the past 40 years, with periodic fluctuations in woody vegetation about the periphery of this area (Fig. C5 and Figs. C19-C23). A tract of about 1,400 acres of woody vegetation was present on the higher elevations of the point bar in 1952, the earliest available aerial photograph. This vegetation stand expanded downstream and channelward through 1966, as the point bar accreted and grew in elevation. From 1966 through 1975, vegetated area on the point bar remained relatively constant. Over the next ten years, however, vegetation declined about 25 percent as a result of erosion caused by development of a secondary channel through the downstream portion of the point bar and clearing of woods for agriculture. Beginning in 1987, the trend reversed and by 1992 woody vegetation coverage was near 1972 amounts as scattered patches of willows developed on the northern face of the point bar.

The amount of bare sandbar varied with time, being generally greater in 1988-91 than in 1952 and 1962. The large decrease in area between 1962 and 1976 was probably a result of the 1973 flood and development of the secondary channel described previously. The elongate section of isolated point bar between RM 806 and 808 (Fig. C5) supports the largest least colony on the Mississippi River.

Hotchkiss Bend-Milton Bell Reach(RM 892.0-909.5)

This reach encompasses Donaldson Point and Slough Bend, the upstream loop of the double bends at New Madrid, Mo. The upstream arm of the bend is a straight reach between Milton Bell Light and Slough Bend, and the downstream arm of the bendway is a moderately sinuous reach that includes Hotchkiss Bend and mid-channel bar. Donaldson Point dike system was built along the right bank (RM 901-906) in 1973 to reduce channel width and stabilize channel alignment.

Additional dikes were added to the system in 1988, 1991, and 1994. Below Island No. 9 dike system (RM 900-902) was constructed in 1982 along the left concave bank of Slough Bend to control channel widening and establish a desirable alignment for the navigation channel. Hotchkiss Bend dike system (RM 893-897) was first constructed in 1984, and two additional dikes were built in 1994, to decrease divided flow and improve depths in the navigation channel. Slough Landing dikes were installed on the bank opposite Hotchkiss Bend dike system to improve navigation channel depths.

In this reach, woody vegetation coverage on sandbars exhibited a cyclic pattern (Fig. C7

and Figs. C24-C30). One sandbar complex was extensively vegetated in the 1950's, but experienced a pronounced decrease in vegetation coverage in the early 1960's. Woody vegetation coverage remained low through the mid 1980's, followed by a period of re-vegetation and expansion through 1992. Woody vegetation was sparse on the other sandbars in the early 1950's followed by an episode of vegetation expansion that peaked in the mid- to late 1960's. A decrease in the amount of woody vegetation occurred in the early 1970's with a resurgence of colonization commencing in the early to mid 1980's and continuing to 1992.

Woody vegetation on the mid-channel bar at Hotchkiss Bend, a sandbar highly used by least terns, has waxed and waned as the bar shifted and re-formed between 1952 and 1992. Between 1957 and 1960, a large sandbar contiguous with the right bank (RM 895) became forested with willows and matured to the point that it was considered fast land and subsequently was not classed as sandbar. The shift from sandbar to fast land caused the marked decline in woody vegetation acreage between 1960 and 1962. During this period the previously small mid-channel sandbar significantly enlarged laterally and vertically and a small patch of woody vegetation became established on the bar's crest. This vegetation stand disappeared after two years and no significant re-colonization took place until 1976 when a small stand of willows became established on the secondary channel side of the bar. Sediment accretion resulted in growth of the sandbar contiguous with the right bank (RM 895.5-897.5). By 1988, probably as a result of prolonged low-discharges during the summers of 1987 and 1988, willows had become established on this narrow sandbar and on the upstream margin of the mid-channel sandbar. By 1991, patches of woody vegetation were present on higher portions of the enlarged mid-channel sandbar and the stand of willows on the sandbar between Hotchkiss Bend dikes No. 1U and No. 2 had expanded channelward (Fig. C8). Bare sandbar area increased between 1974 and 1987 and then declined slightly by 1990.

Active fluvial processes at Slough Bend resulted in a dynamic spatial distribution of sandbar and associated woody vegetation (Fig C7 and Figs. C24-C30). In 1952 woody vegetation was present on the Winchester Point sandbar as well a sandbar contiguous with the concave bank. Point bar cutoff processes had eroded away the sandbar and woody vegetation on Winchester Point by 1962. During this time sandbar on the concave bank in Slough Bend expanded downriver and laterally. From 1969 to 1970, most woody vegetation was lost to sandbar erosion. Subsequently, a mid-channel bar and divided flow conditions developed at Slough Bend, and the Below Island No. 9 dikes were constructed in 1984 to concentrate flows and improve alignment of the navigation channel. Least terns used the bare sand on the mid-channel bar. Several patches of willows became established on Slough Bend sandbar during the low water of 1987 and 1988, and these stands approximately quadrupled in size by 1992. In 1994, two large stone dikes with weir sections were constructed on Winchester Point to improve channel alignment. Thereafter, Slough Bend mid-channel bar was significantly reduced in size and elevation with attendant loss of woody vegetation.

A narrow, elongated sandbar has persisted along the right bank between RM 902-906 throughout the period of record. Aerial coverage of woody vegetation on this sandbar varied significantly from year to year, as the sandbar aggraded and degraded over time (Fig. C7 and Figs. C24-C30). Several peaks in area occurred in the 1960's followed by a gradual increase from 1970-1987. The amount of woody vegetation nearly tripled in 1988 as a result of colonization of low-elevation sandbar that was emergent during the prolonged low-discharges of 1987 and 1988. A 20 percent decrease in vegetation occurred between 1988 and 1991, probably due to mortality of willow seedlings established at low elevations in 1987-88.

At Island No. 9, a large patch of woody vegetation was present on the left bank sandbar from the early 1950's throughout 1969 (Fig. C7 and Figs. C24-C30). By 1970, willows in this stand had matured and the topography was such that this area was subsequently classed as fast land. This conversion of sandbar to fast land resulted

in the pronounced decrease of woody vegetation acreage from 1969-1970. A second mid-channel bar lacking vegetation was evident in 1970 between RM 907 and 908. This bar continued to accrete and expand upstream and downstream from 1970 to 1992 and woody vegetation colonized and spread annually across higher elevations of the bar through 1992.

Pritchard-Island No. 1 Reach.

This is a very straight reach extending from Campbell Point at RM 943 to the mouth of Mayfield Creek, Ky. at RM 950. An elongated mid-channel sandbar is located on the left bank and a smaller sandbar is contiguous with the right bank between RM 943 and 945.

Three sections of bank are stabilized with approximately five miles of ACM revetment. Island No. 1 dike system is comprised of 8 stone dikes constructed from 1967-91 along the right bank. Pritchard dike system, built in 1970, is located on the right bank (RM 943.5-945.0). These dike systems were constructed to achieve a desirable navigation channel alignment.

Only a few acres of willows were present on sandbars in this reach from 1957 to 1964. No significant amount of woody vegetation became established during the period of record on the right bank sandbar adjacent to Island No. 1, probably because topographic relief remained low. On the sandbar at Pritchard Point (RM 943-945) a general upward trend in vegetated area began in 1965 that continued to 1991 (Fig. C9 and Figs. C31-C33). Woody vegetation coverage at Pritchard Point sandbar fluctuated markedly from 1965 through 1985, after which time there was a steady upward trend through 1992.

Figure C1. Seedlings and several age classes of black willow on Lower Mississippi River mid-channel sandbar. Note surface deposit of silt-clay sediment overlaying sand substrate.

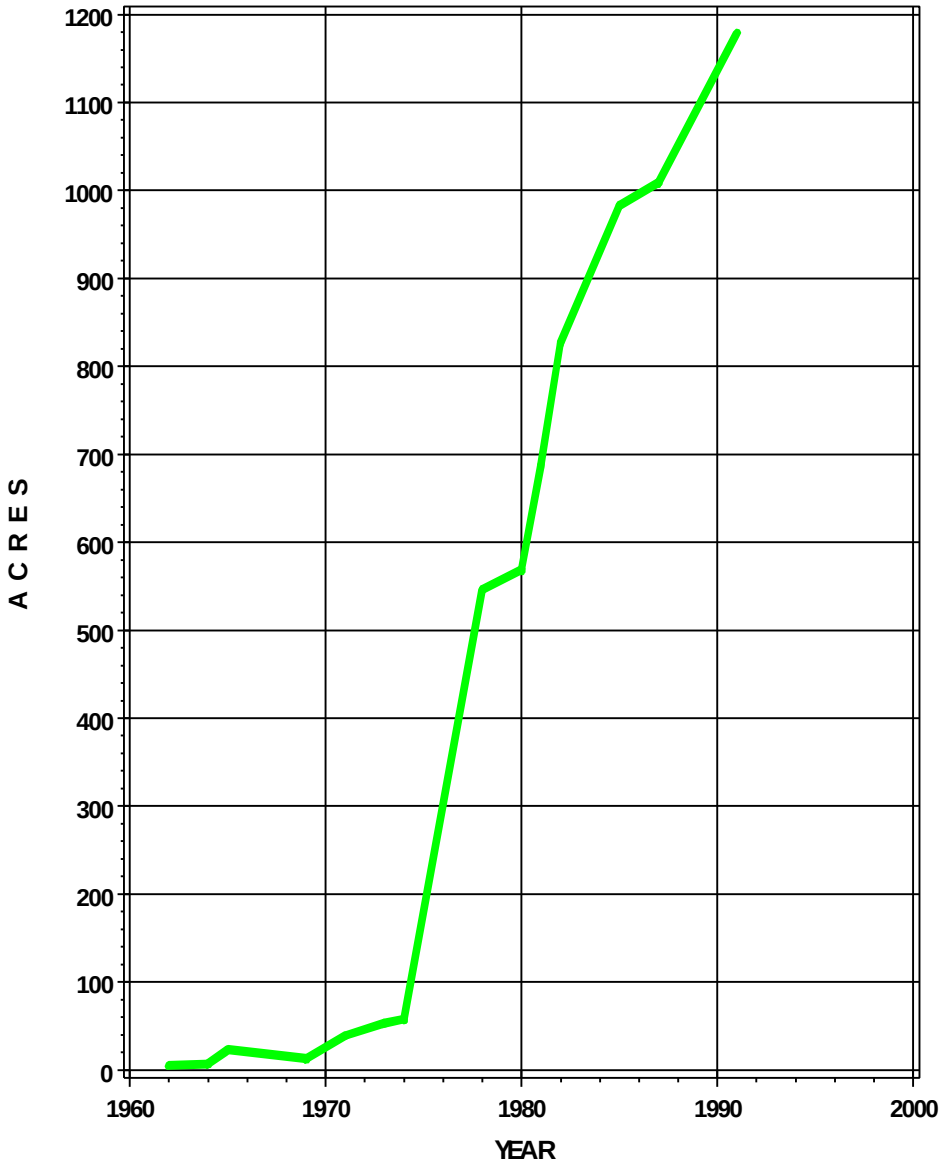

Figure C2. Sandbar vegetation trends, Cracraft -Carolina reach, Lower Mississippi River.

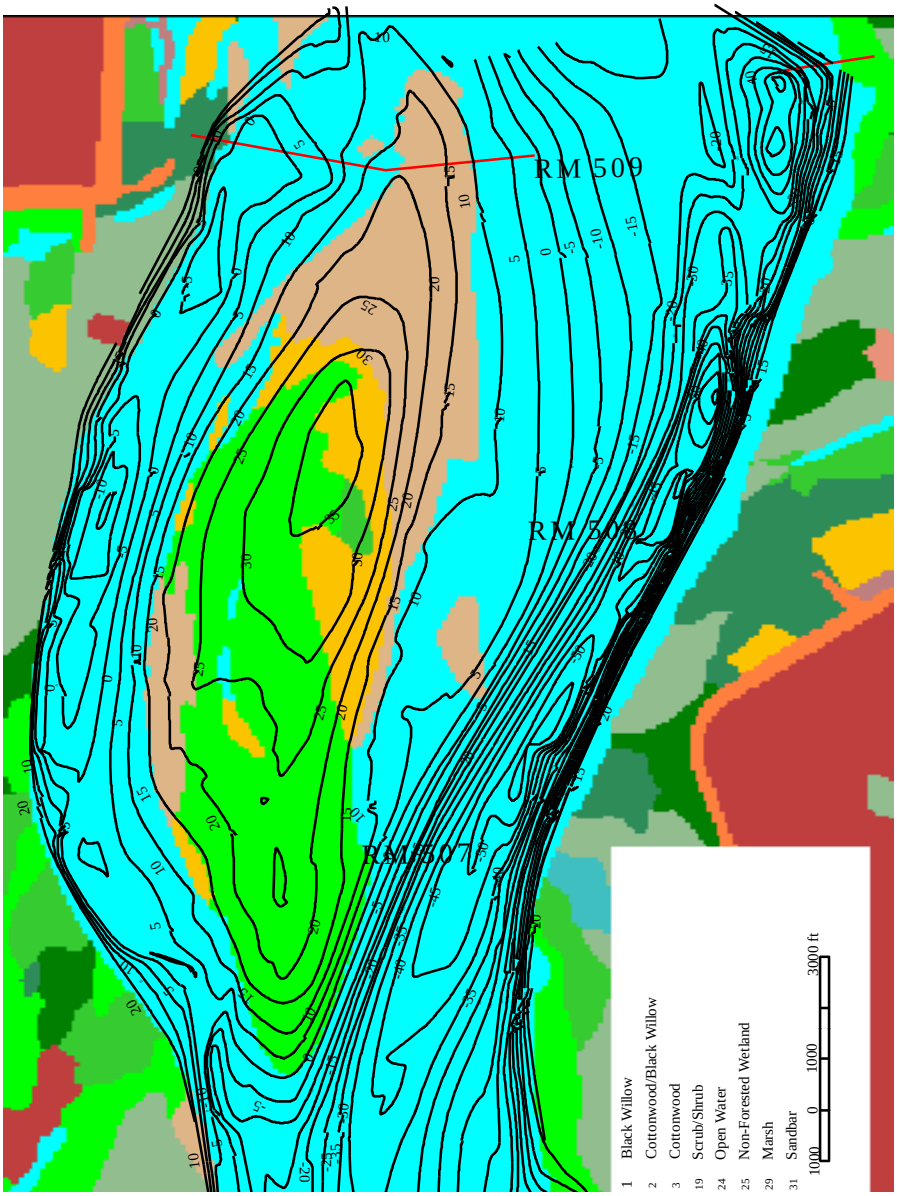

Figure C3. Sandbar vegetation and elevations, 1992, Cracraft Bar, Lower Mississippi River.

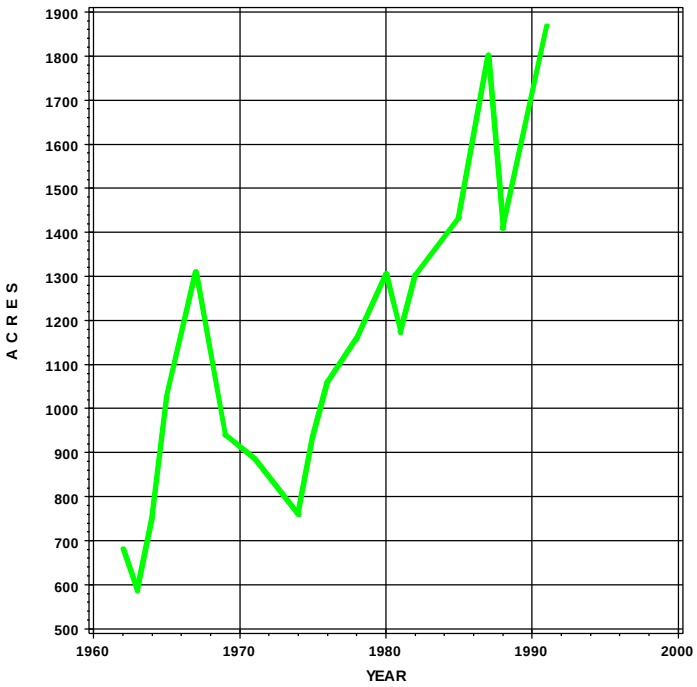

Figure C4. Temporal trend in sandbar woody vegetation, Choctaw Bar reach, RM 555 -566, Lower Mississippi River.

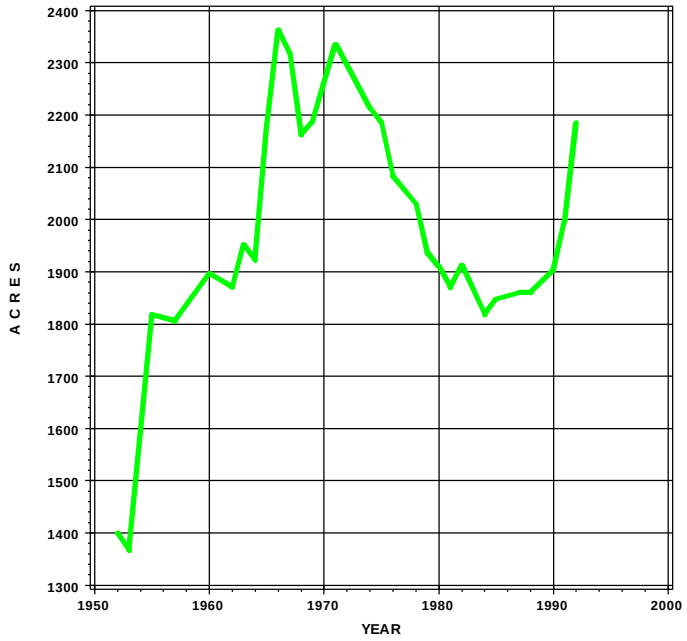

Figure C5. Sandbar vegetation trends, Nebraska Point -Barfield Bend reach, RM 806-813, Lower Mississippi River.

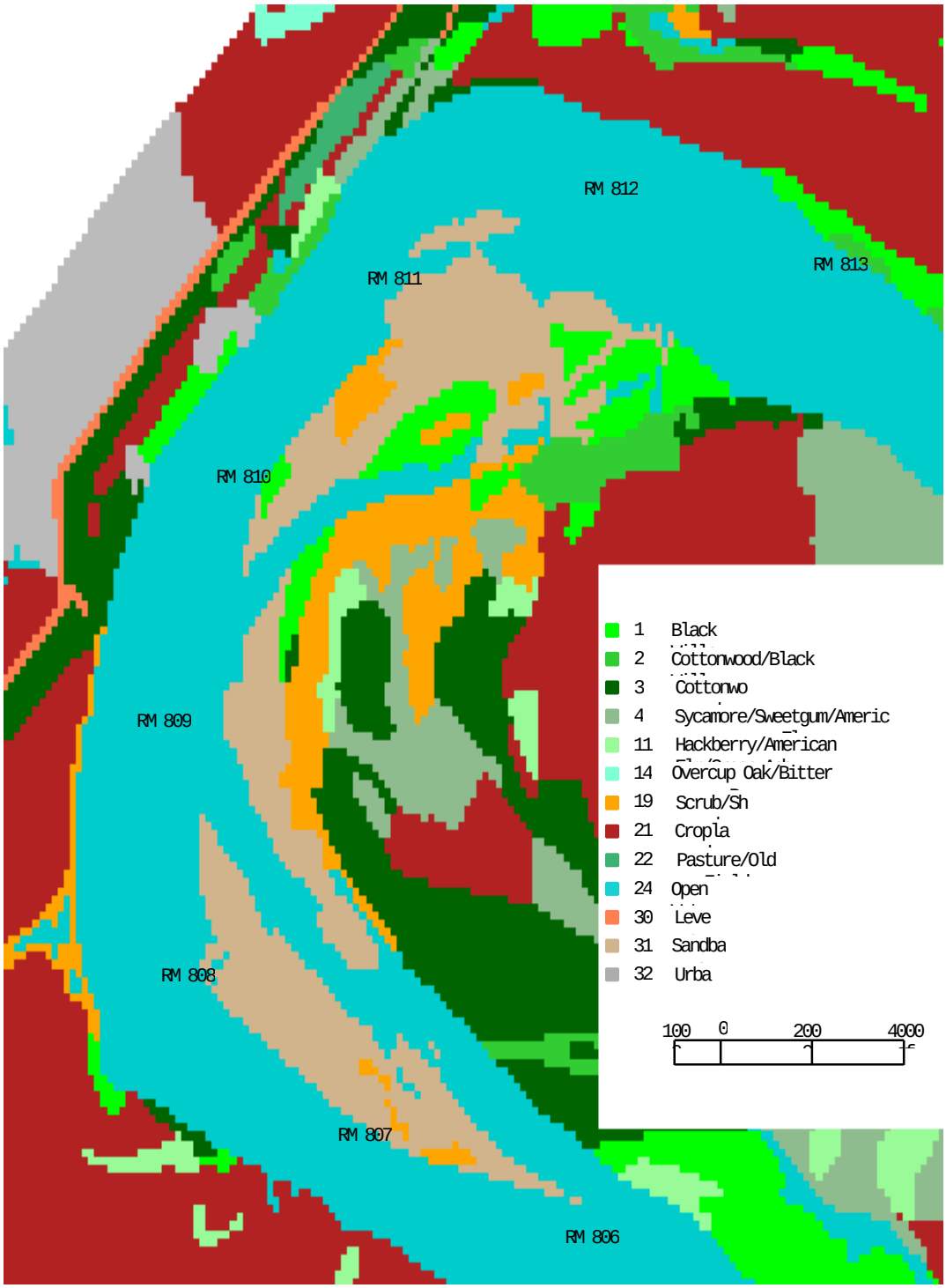

Figure C6. Sandbar vegetation, 1992, Nebraska Point, Tennessee, Lower Mississippi River.

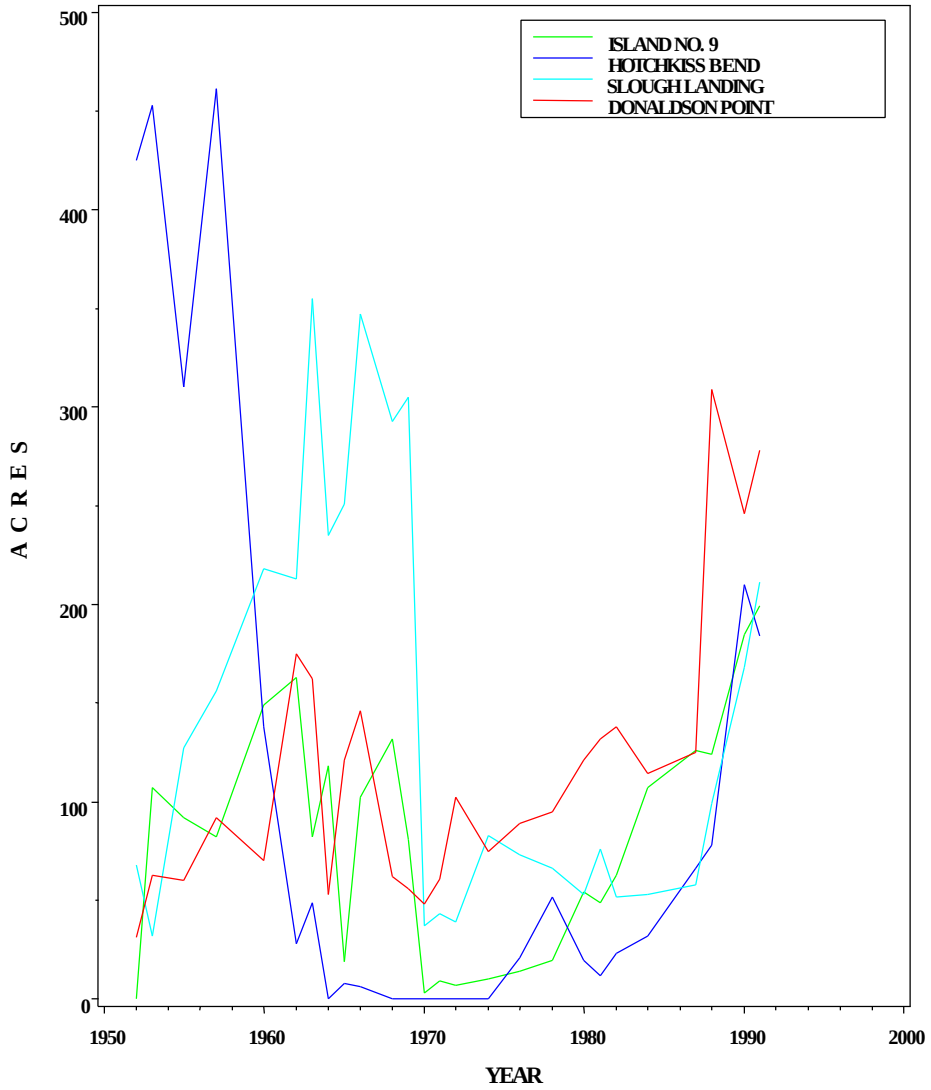

Figure C7. Sandbar vegetation trends, Hotchkiss Bend-Melton Bell reach, RM 892.0-909.5, Lower Mississippi River.

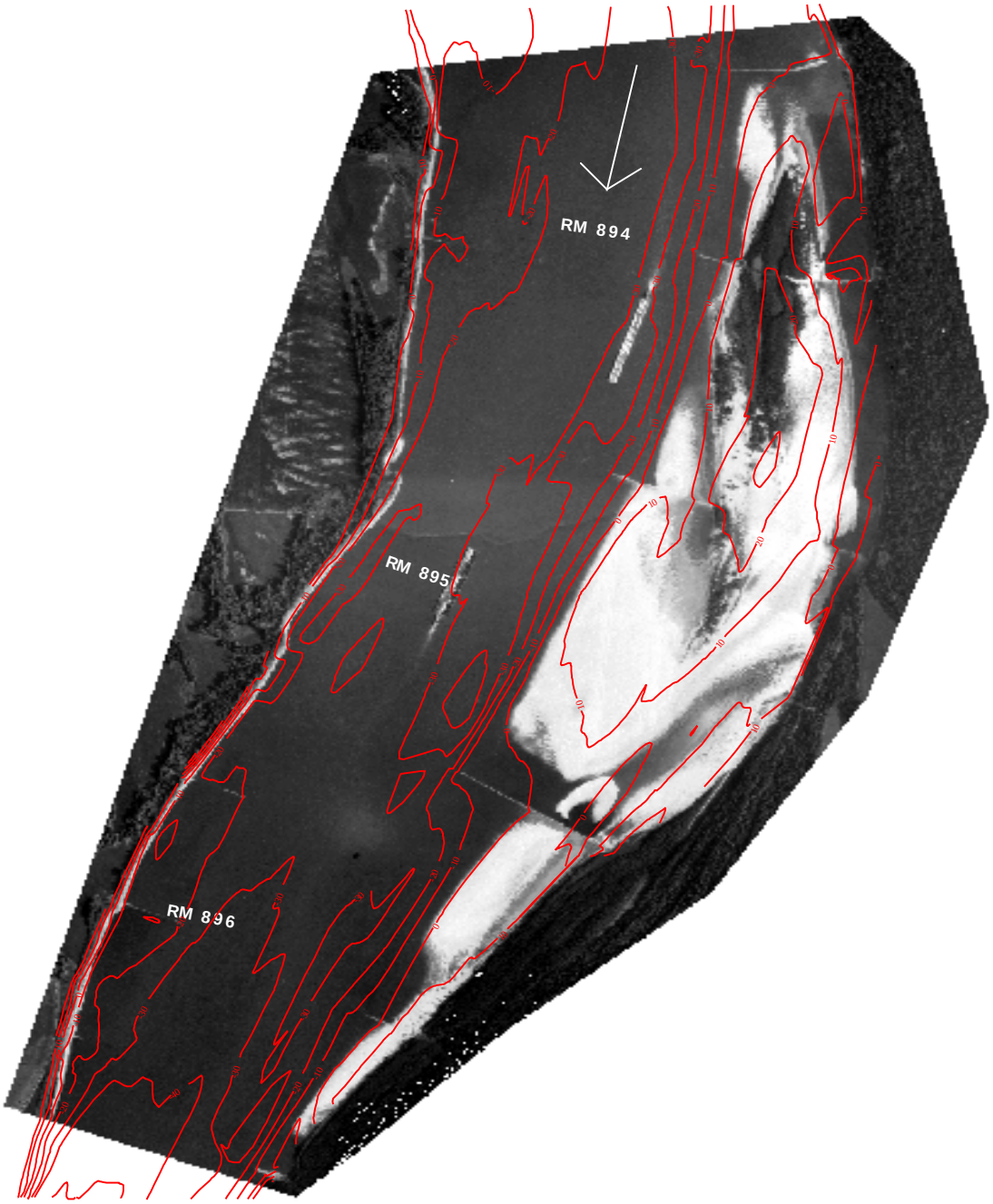

Figure C8. Sandbar vegetation distribution by elevation, 1994, Hotchkiss Bend, Missouri, Lower Mississippi River. Contours in ft, LWRP74.

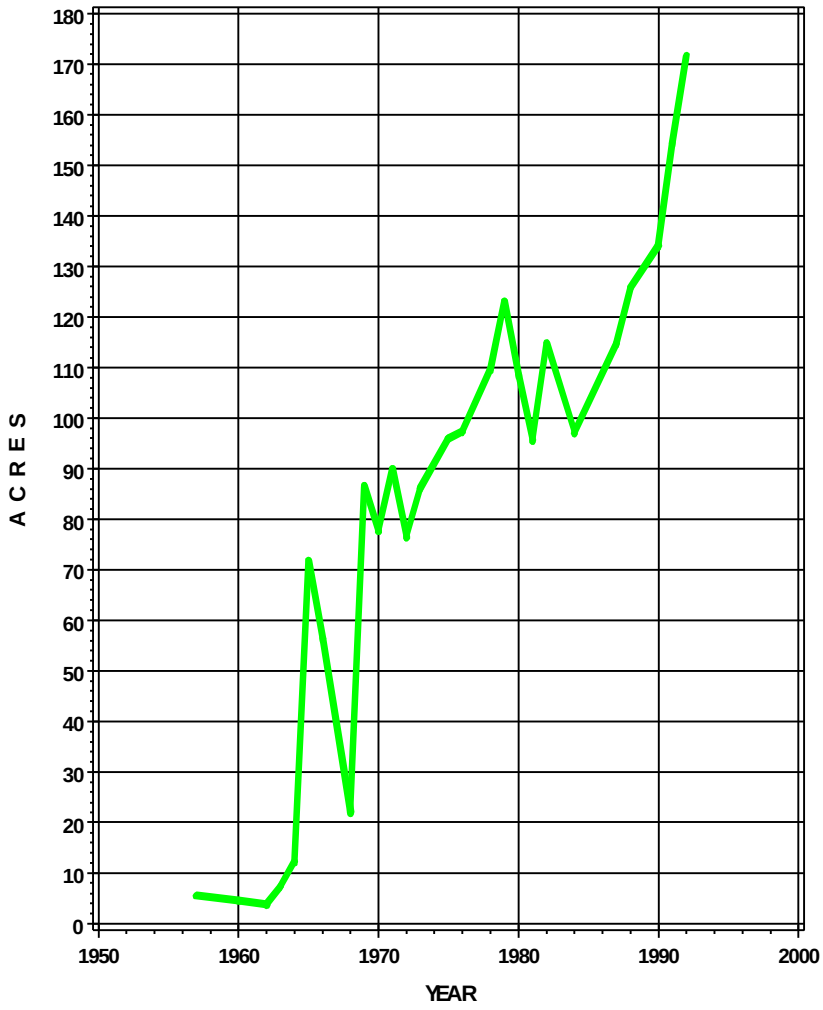

Figure C9. Sandbar vegetation trends, Pritchard -Island No. 1 reach, RM 943-950, Lower Mississippi River.

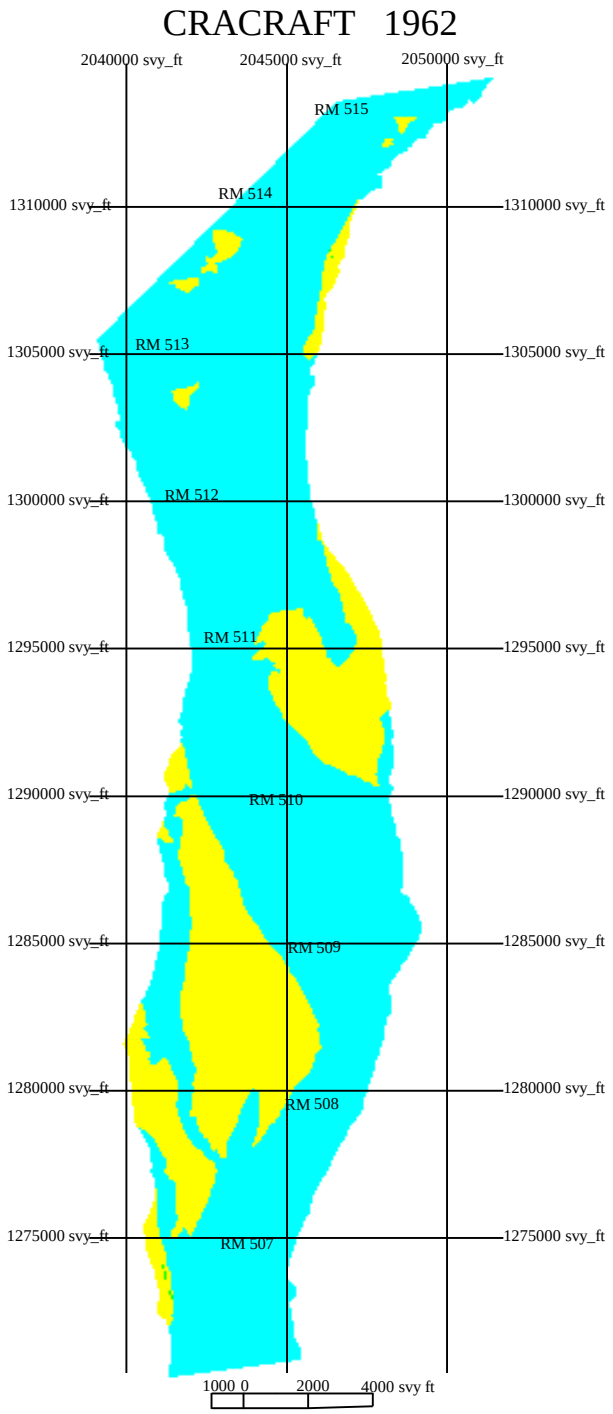

Figure C10. Sandbar vegetation, 1962, Cracraft -Carolina Reach, RM 507-515, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

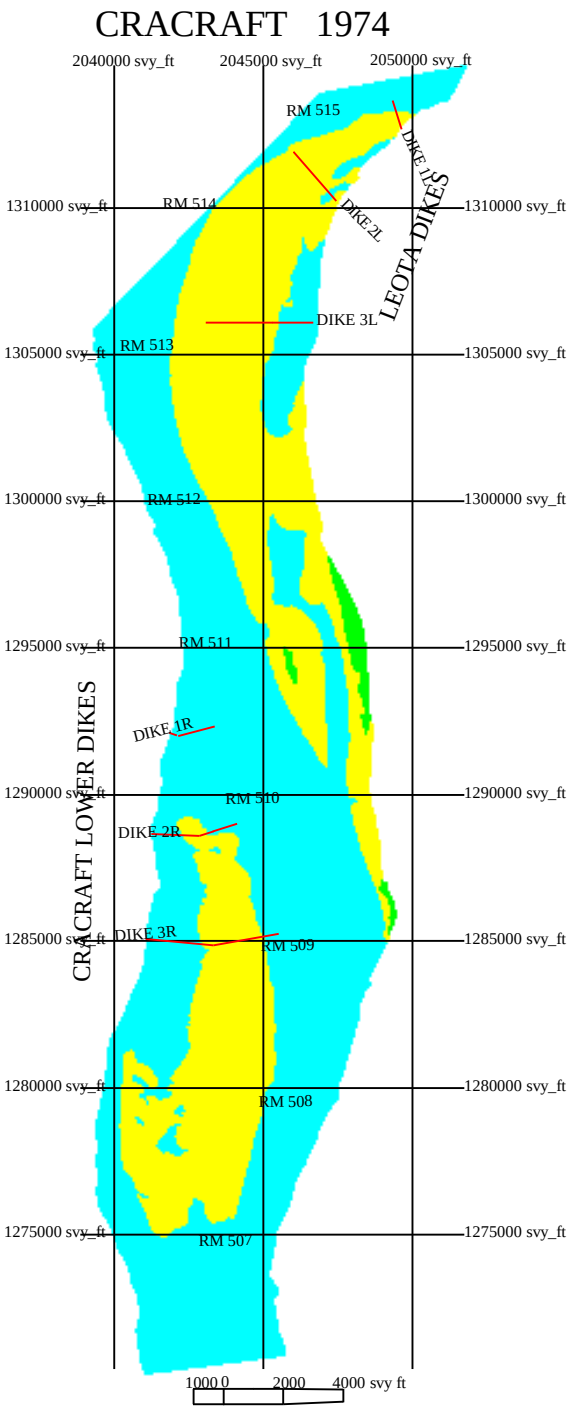

Figure C11. Sandbar vegetation, 1974, Cracraft -Carolina Reach, RM 507-515, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

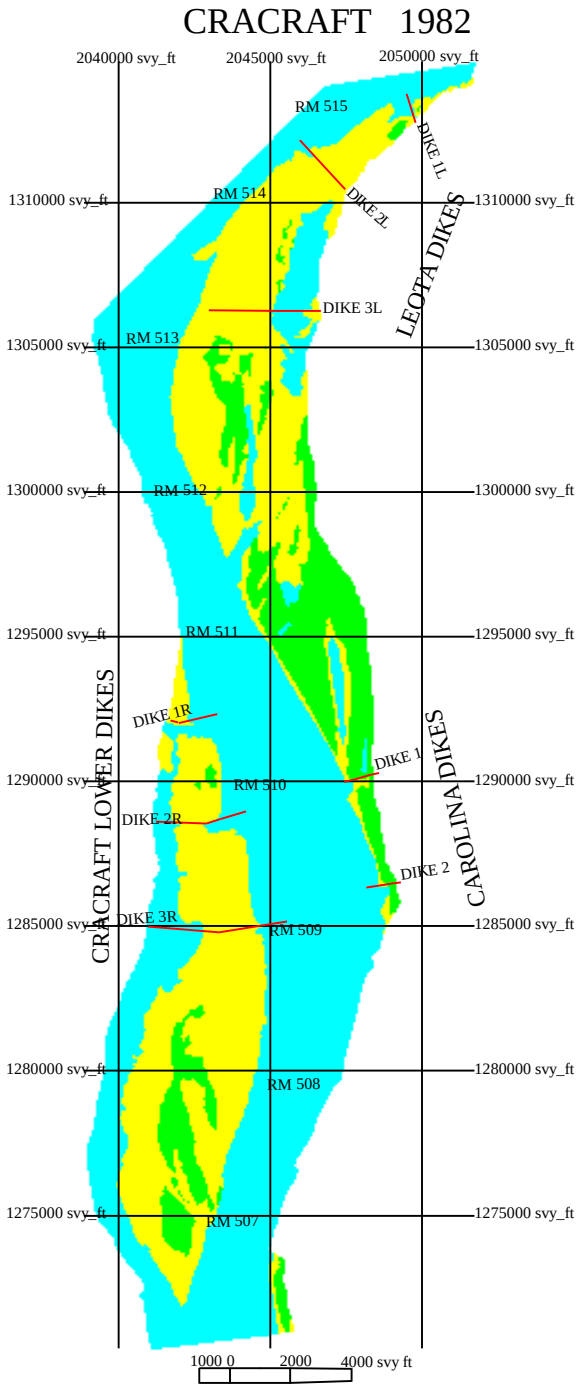

Figure C12. Sandbar vegetation, 1982, Cracraft -Carolina Reach, RM 507-515, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

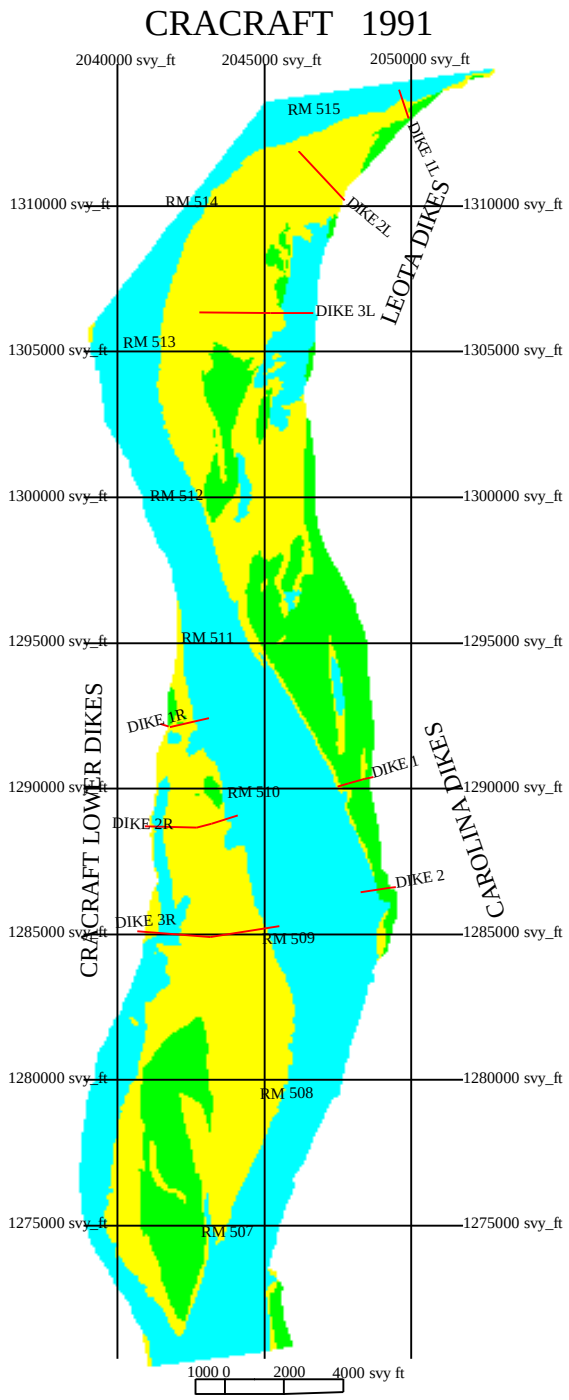

Figure C13 . Sandbar vegetation, 1991, Cracraft -Carolina Reach, RM 507-515, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

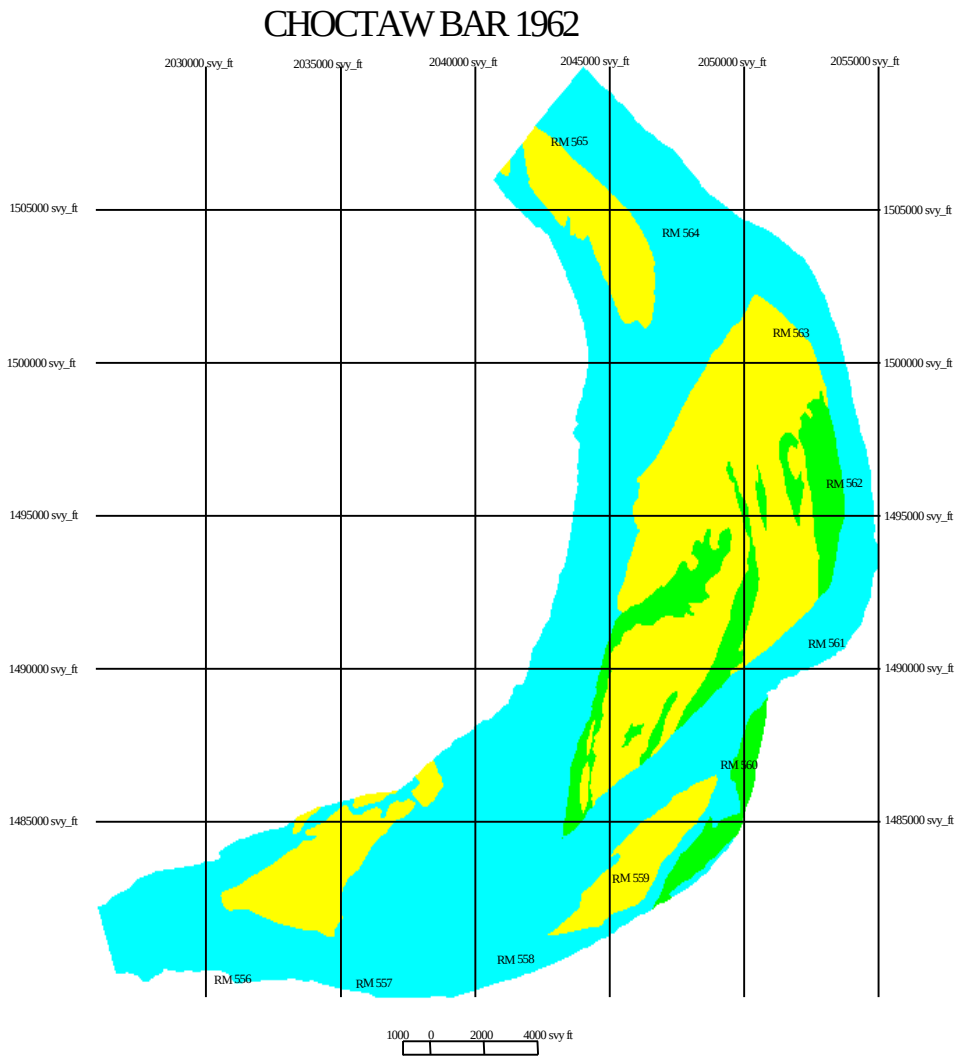

Figure C14. Sandbar vegetation, 1962, Choctaw Bar, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

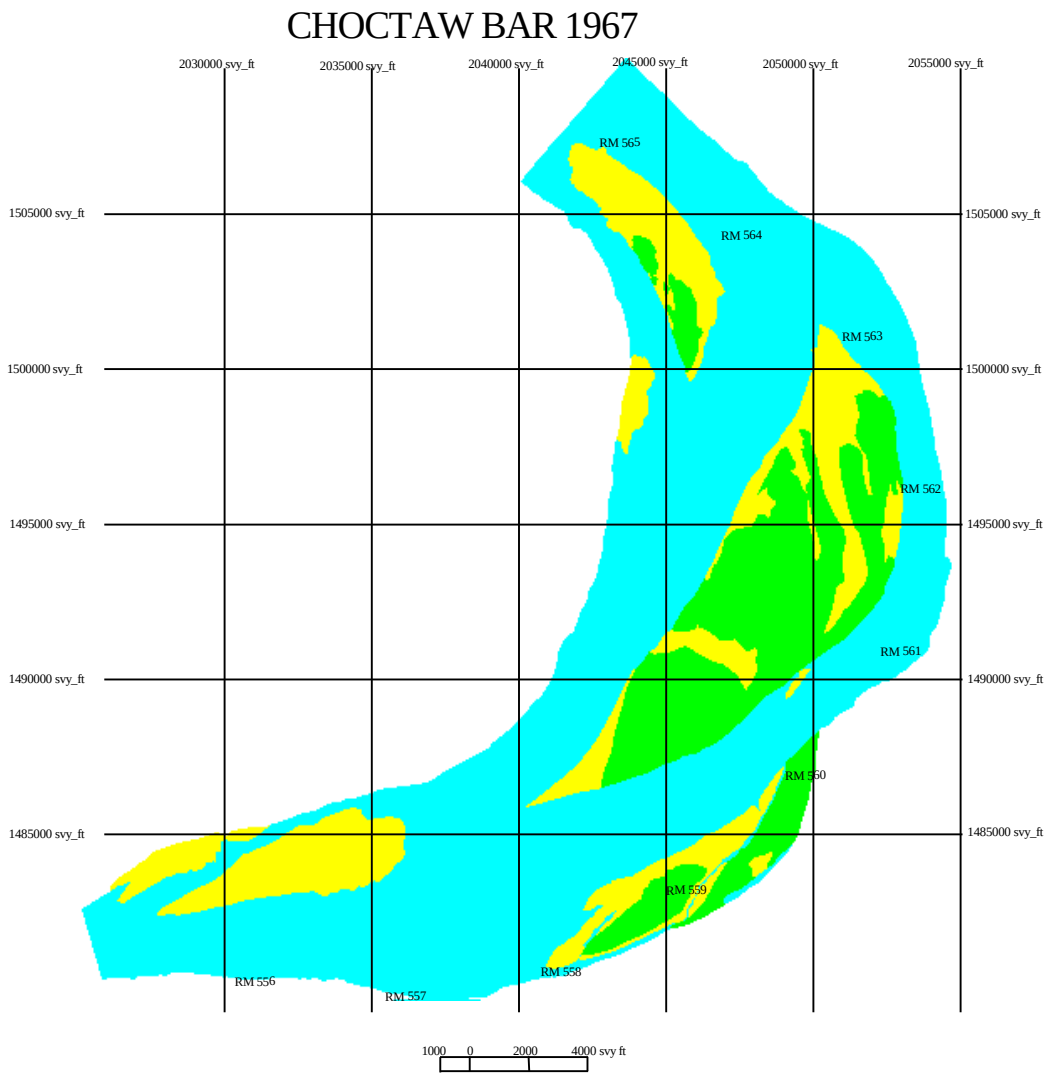

Figure C15. Sandbar vegetation, 1967, Choctaw Bar, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation)

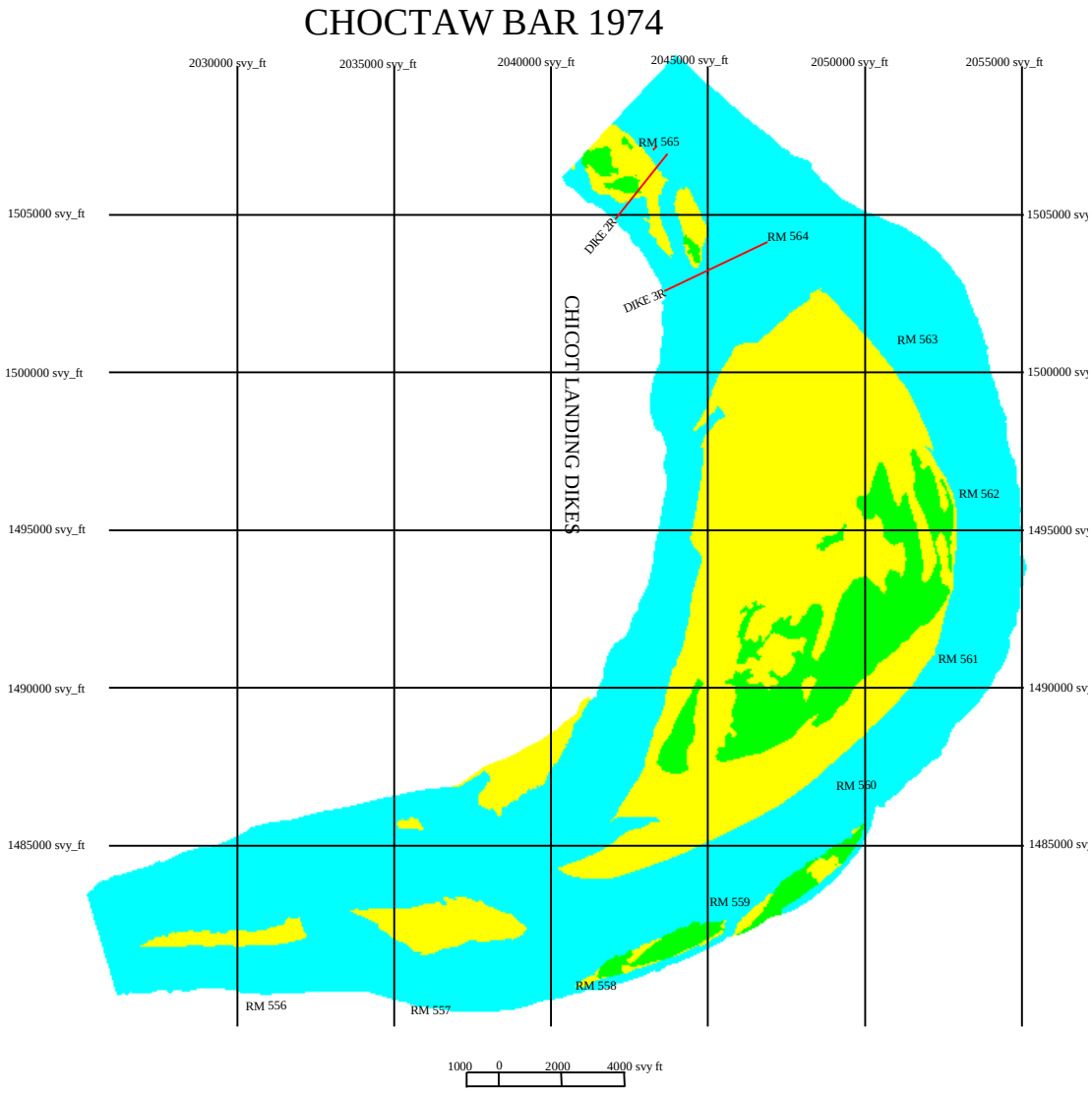

Figure C16. Sandbar vegetation, 1974, Choctaw Bar, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

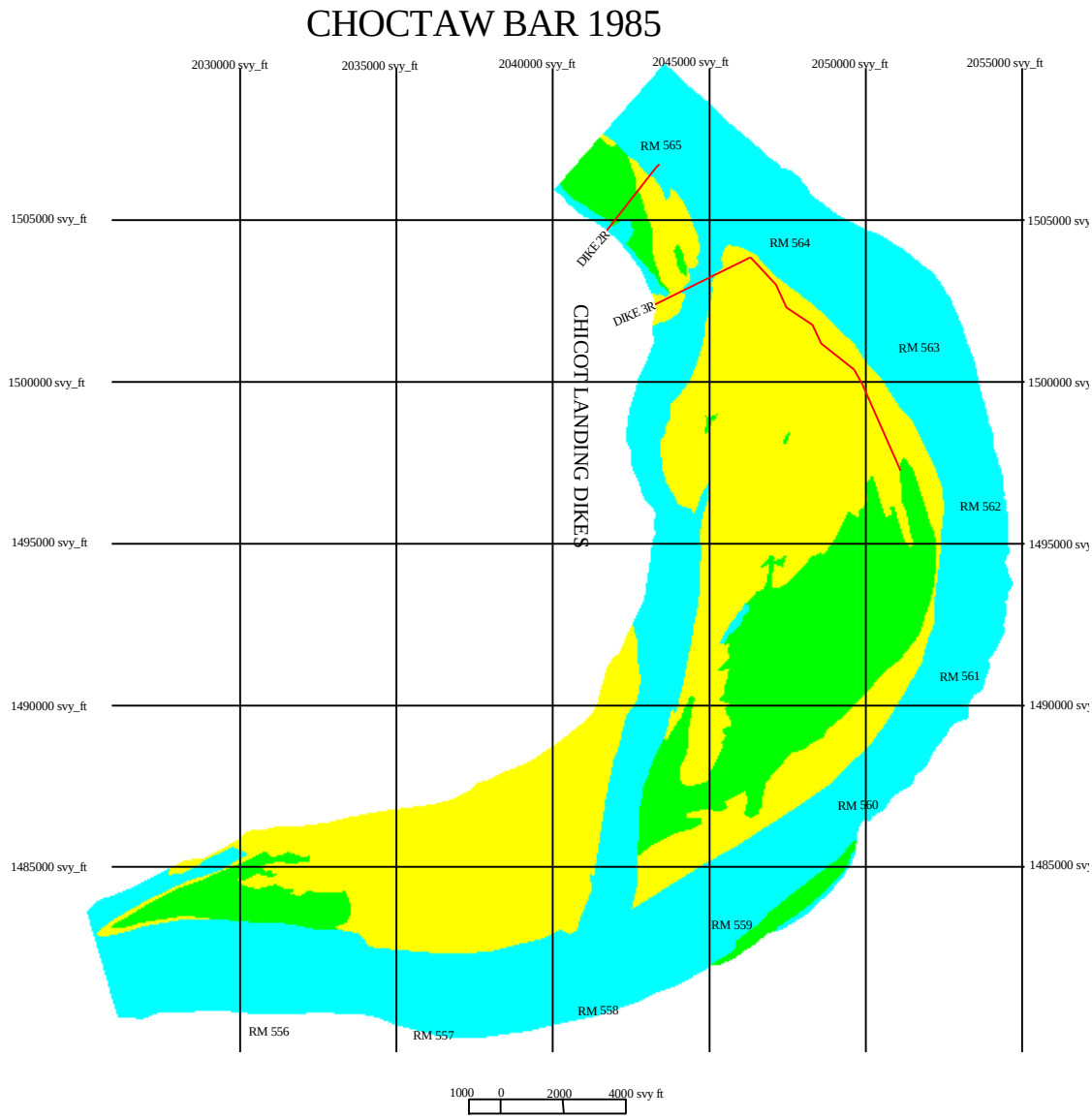

Figure C17. Sandbar vegetation, 1985, Choctaw Bar, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

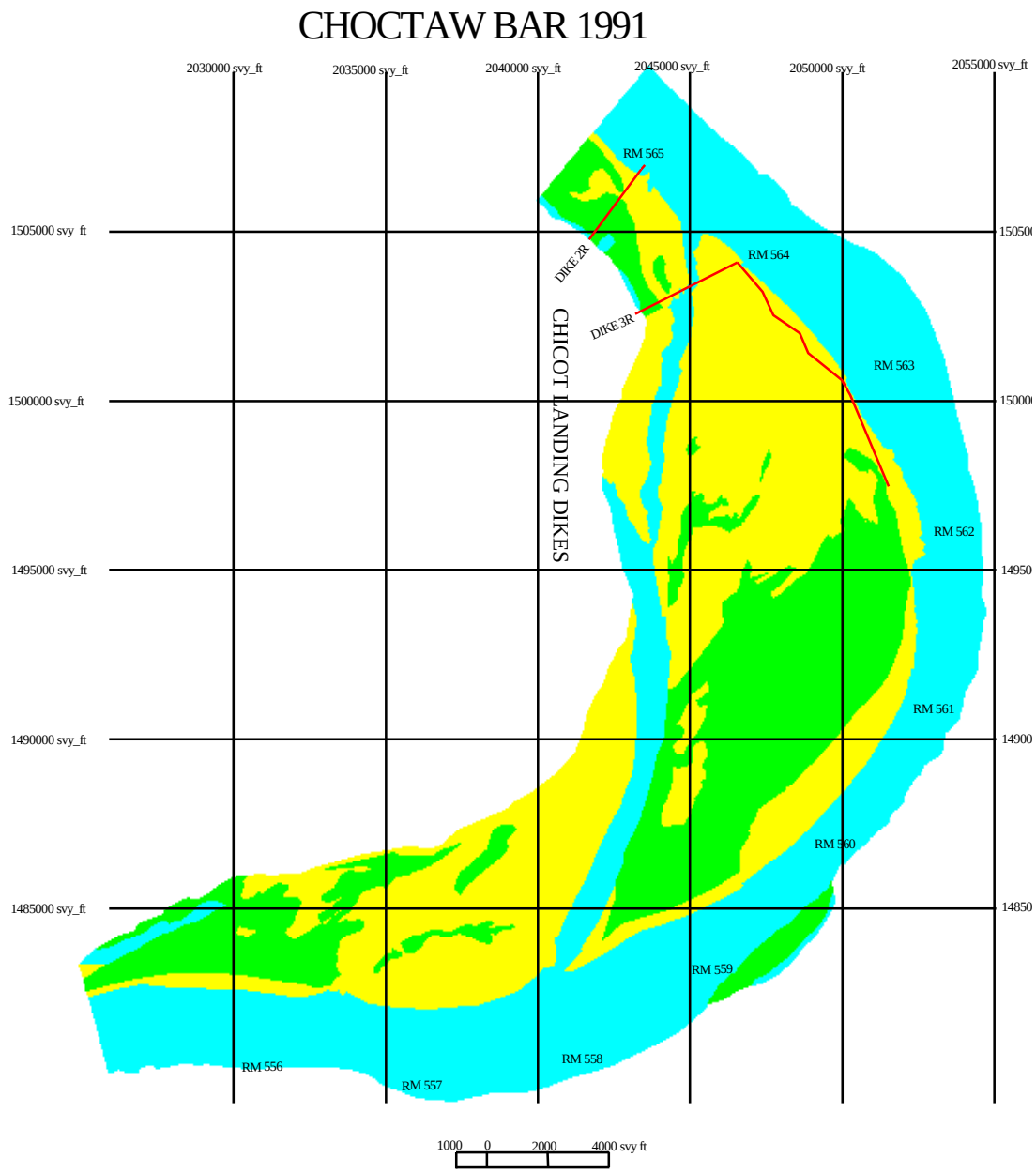

Figure C18. Sandbar vegetation, 1991, Choctaw Bar, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

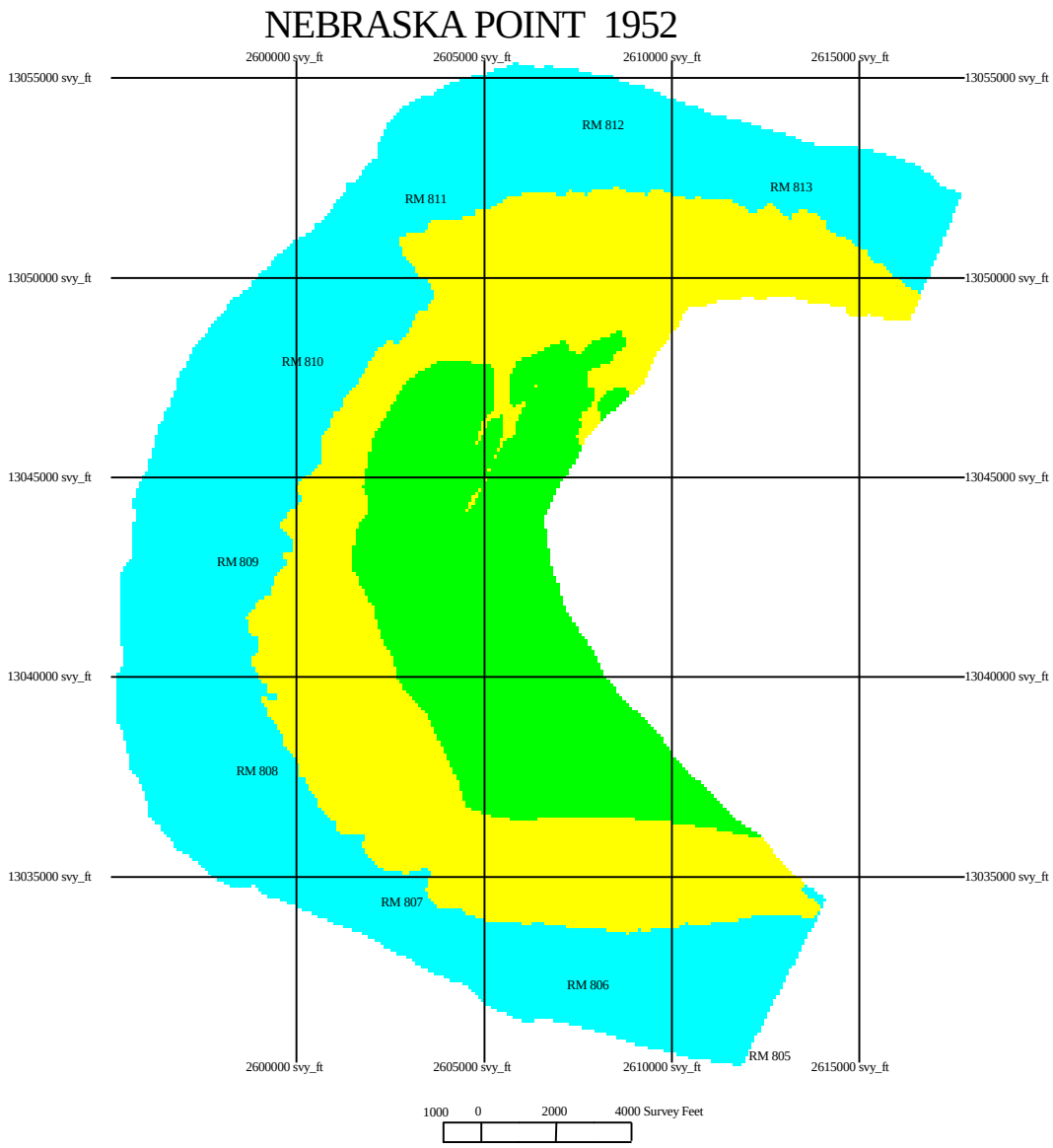

Figure C19. Sandbar vegetation, 1952, Nebraska Pt., Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

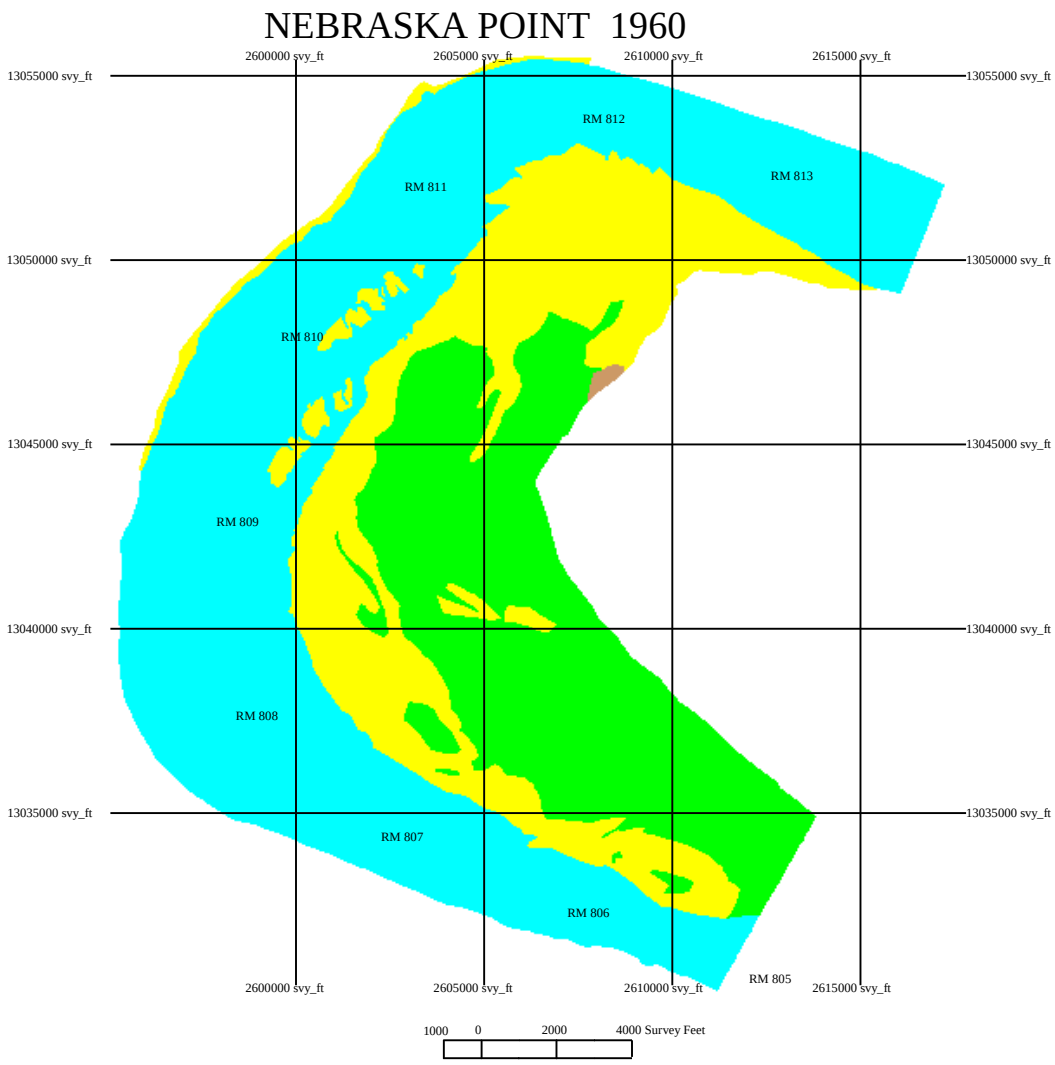

Figure C20. Sandbar vegetation, 1960, Nebraska Pt., Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

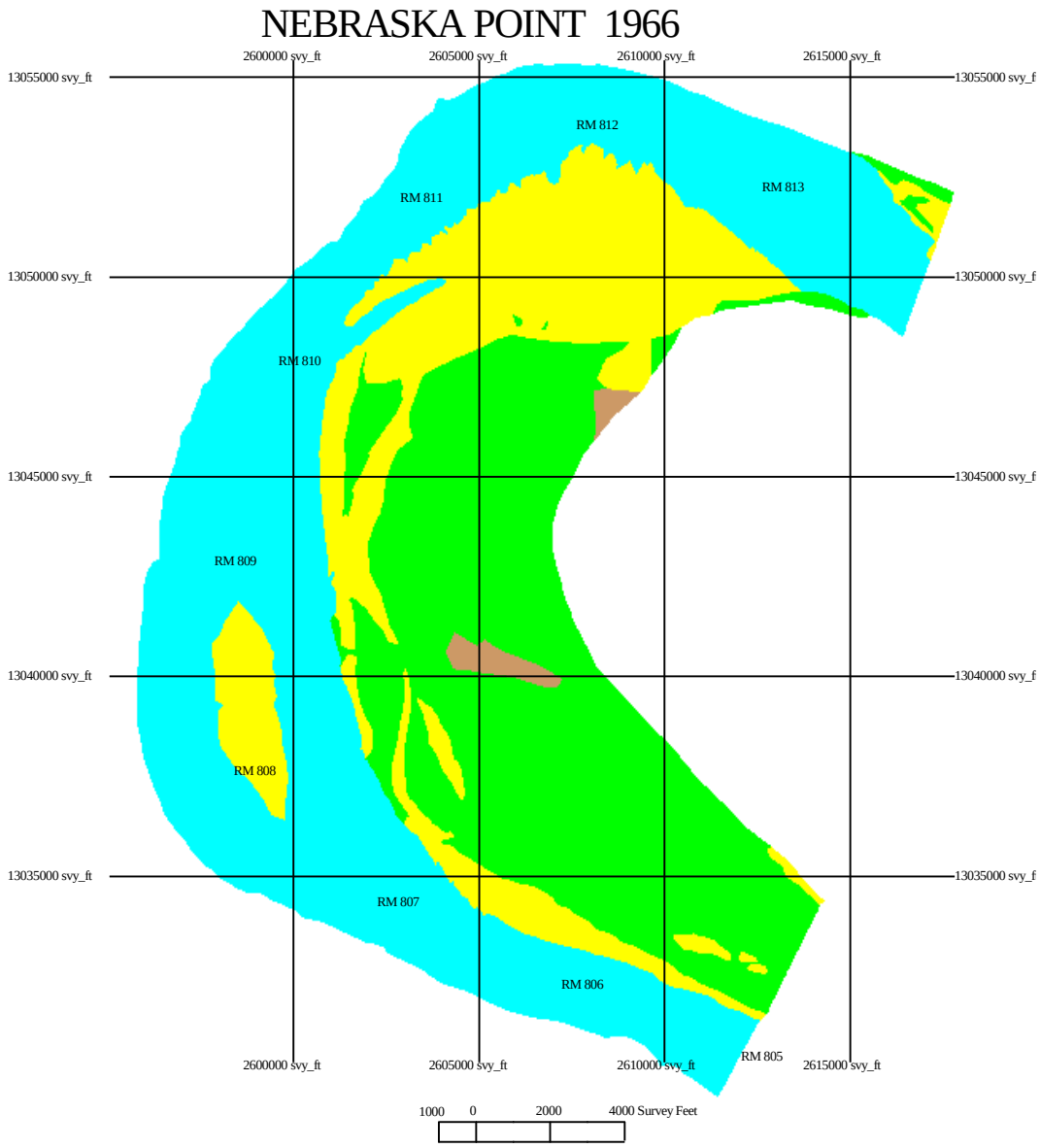

Figure C21. Sandbar vegetation, 1966, Nebraska Pt., Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation, brown = cleared land).

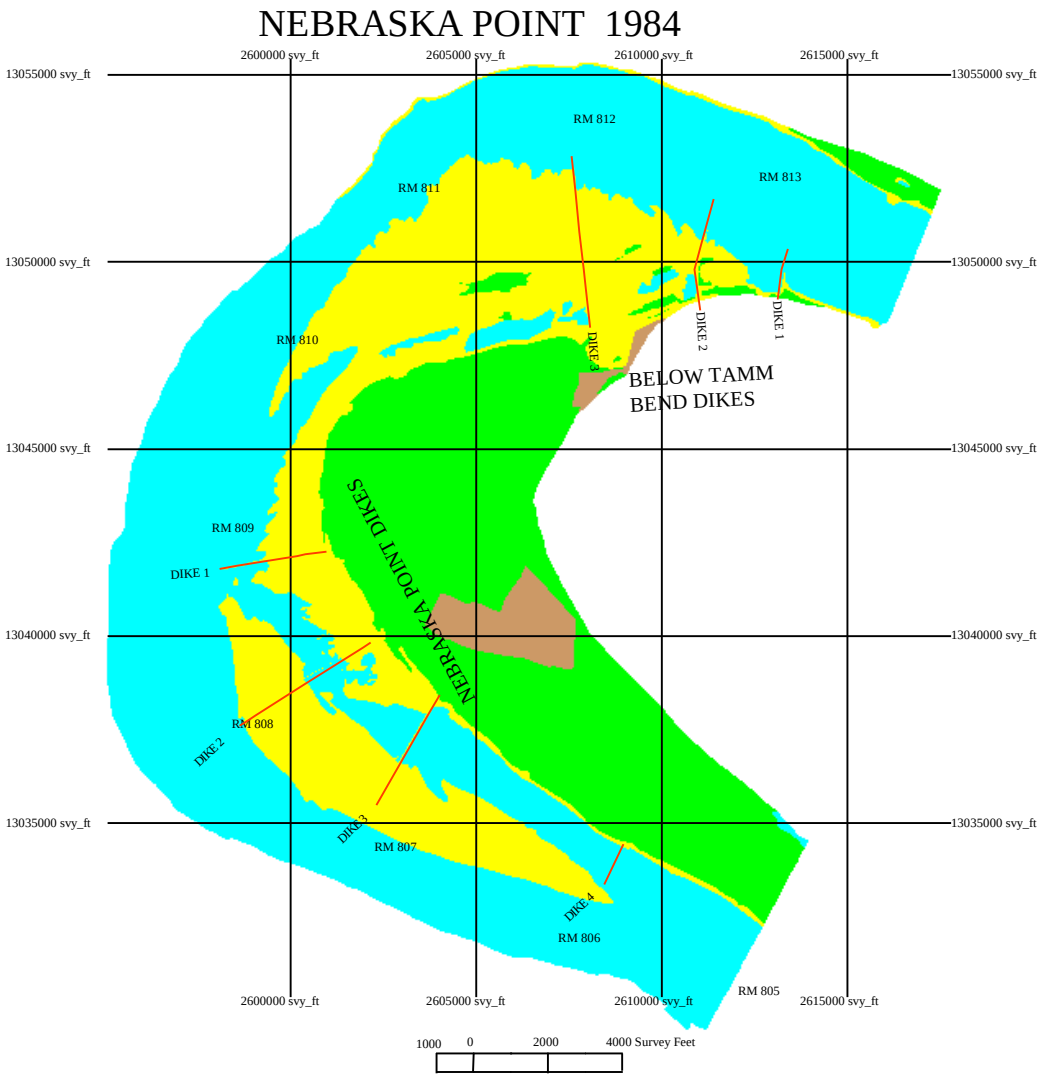

Figure C22. Sandbar vegetation, 1984, Nebraska Pt., Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation, brown = cleared land).

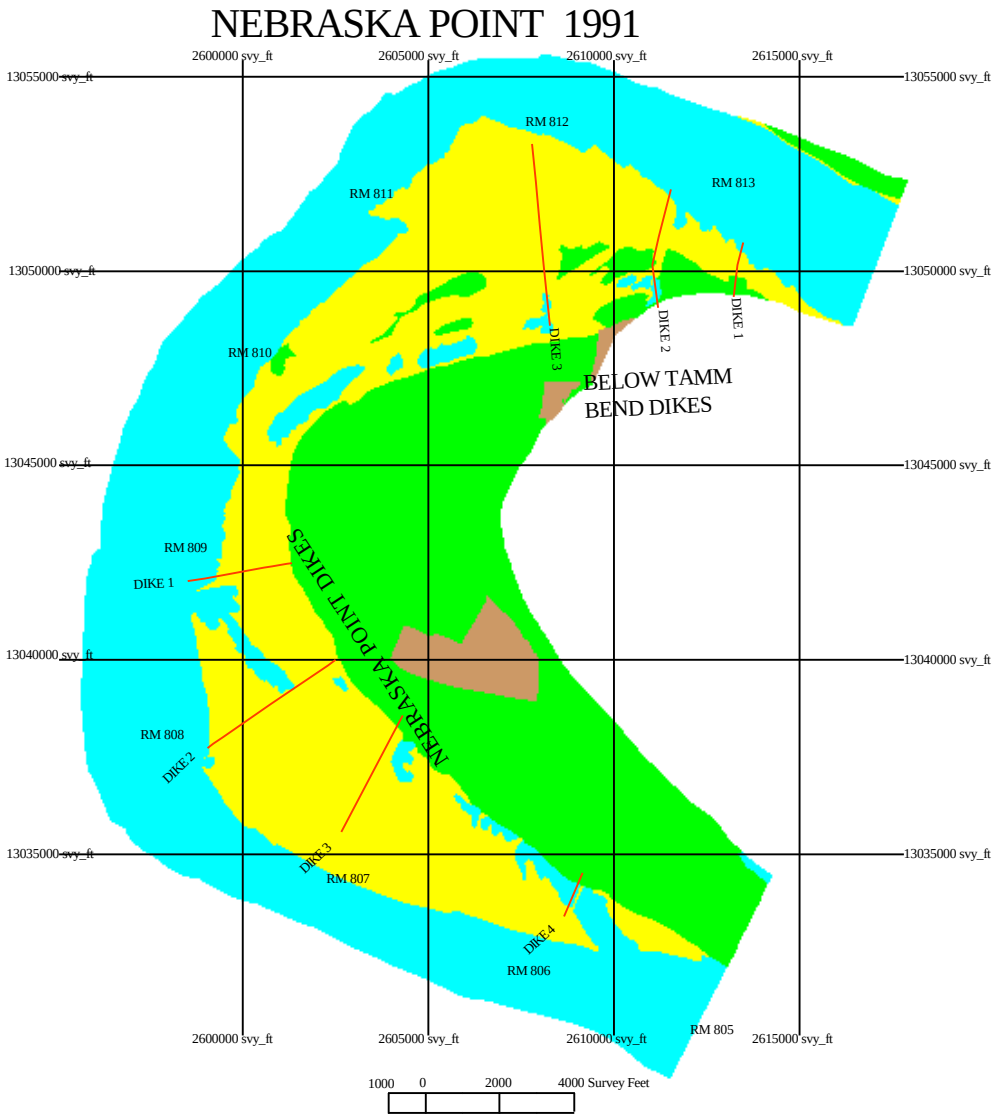

Figure C23. Sandbar vegetation, 1991, Nebraska Pt., Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation, brown = cleared land).

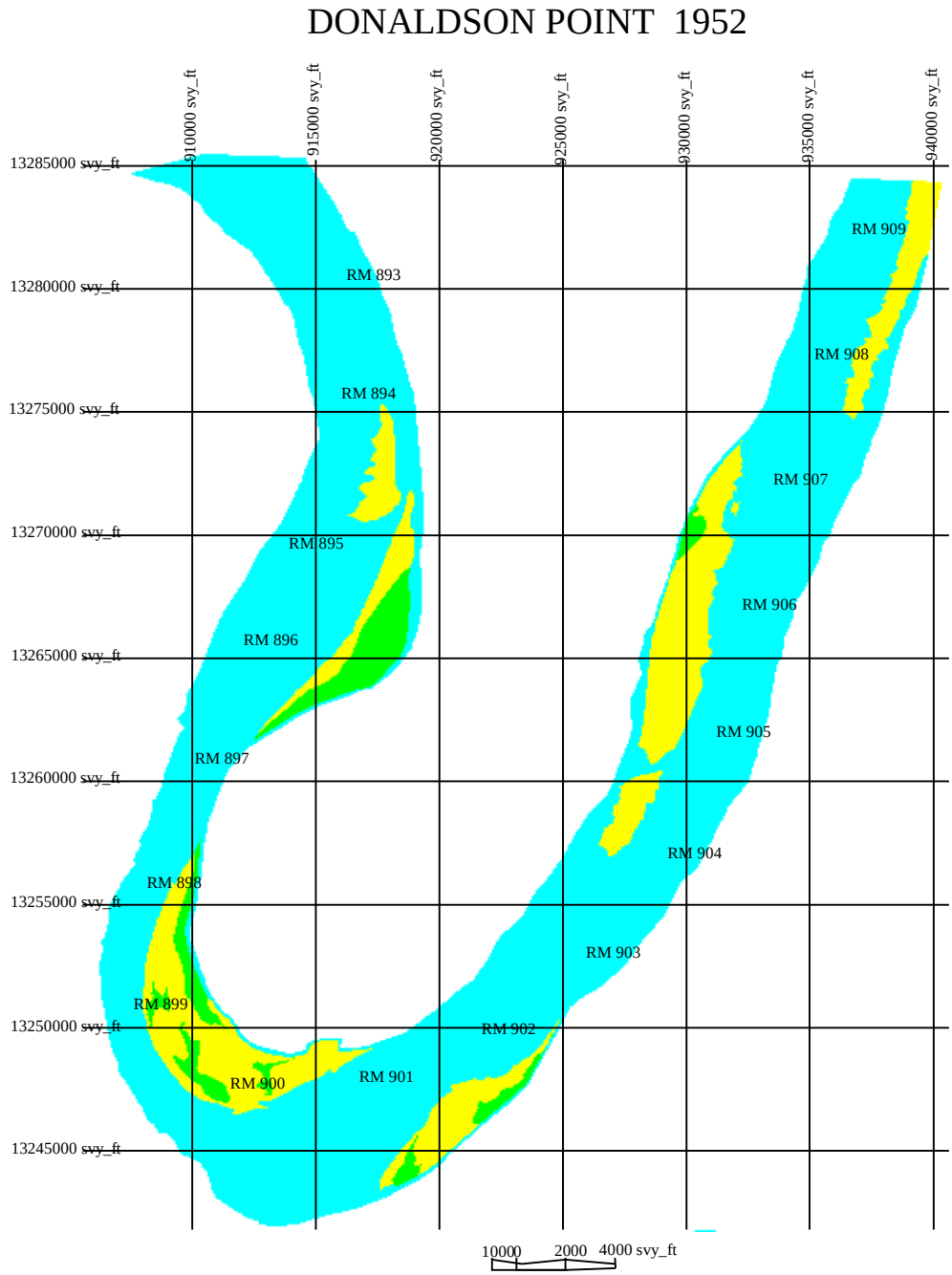

Figure C24. Sandbar vegetation, 1952, Hotchkiss Ben d to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

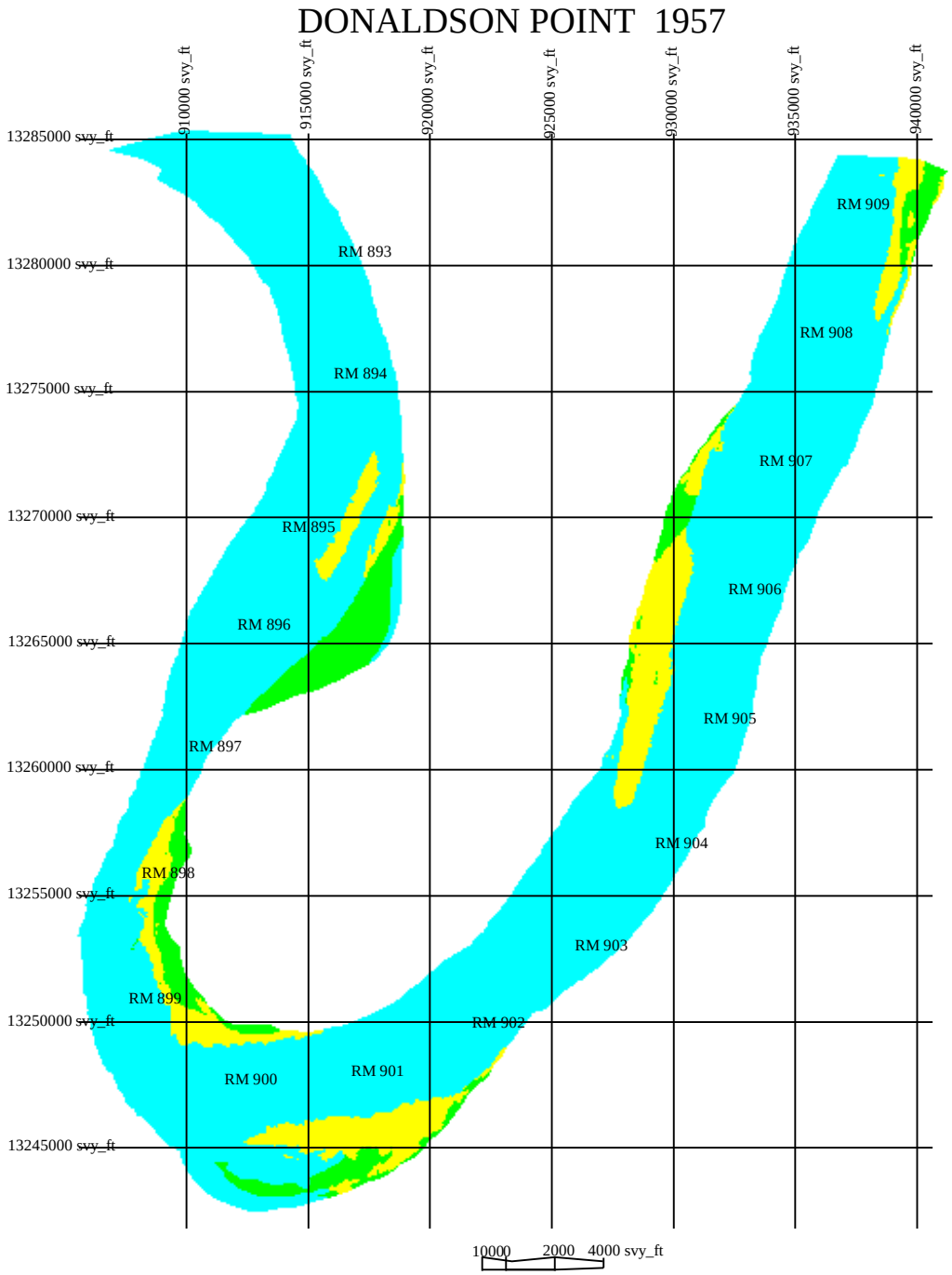

Figure C25. Sandbar vegetation, 1957, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetatio n).

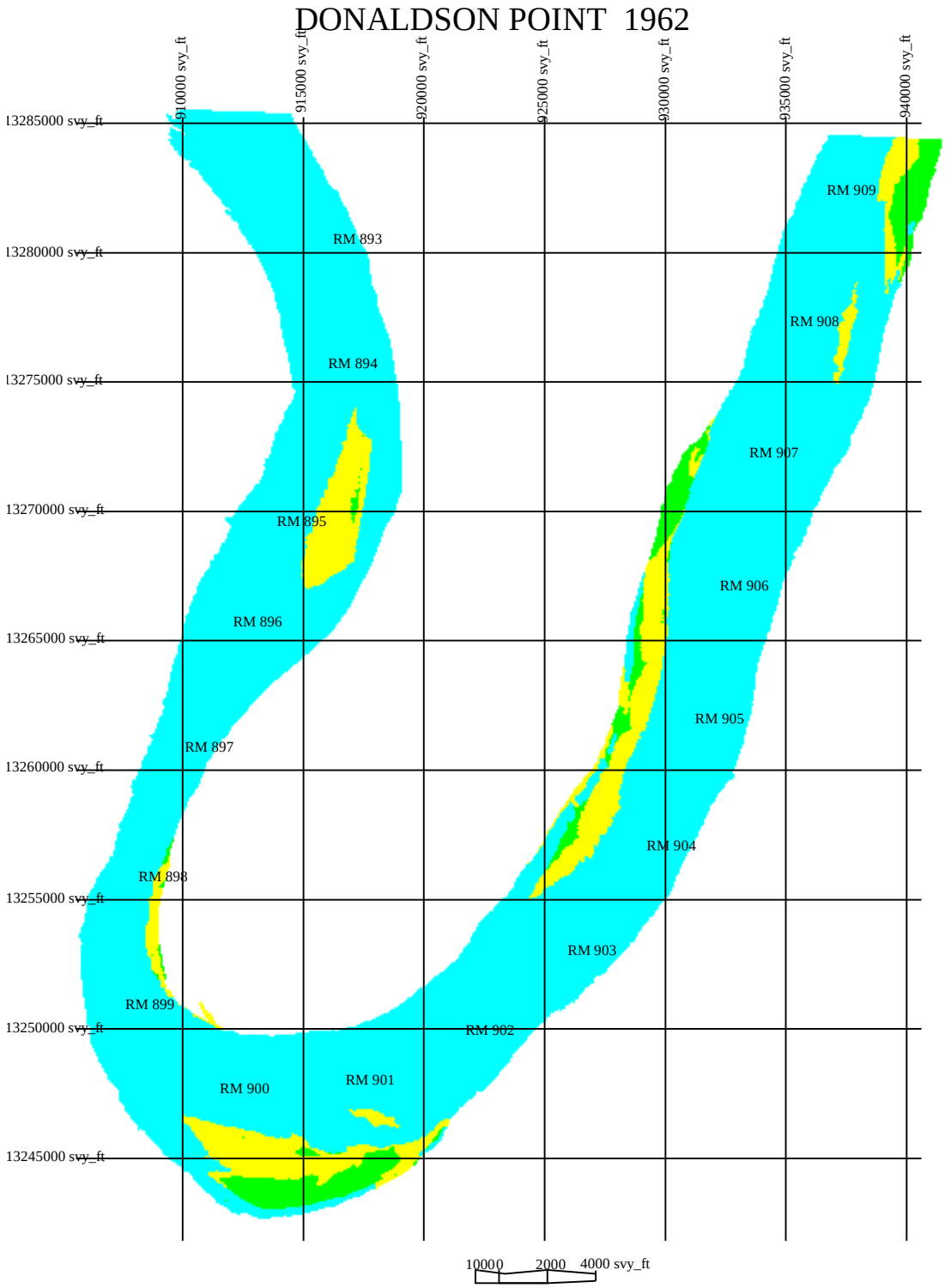

Figure C26. Sandbar vegetation, 1962, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

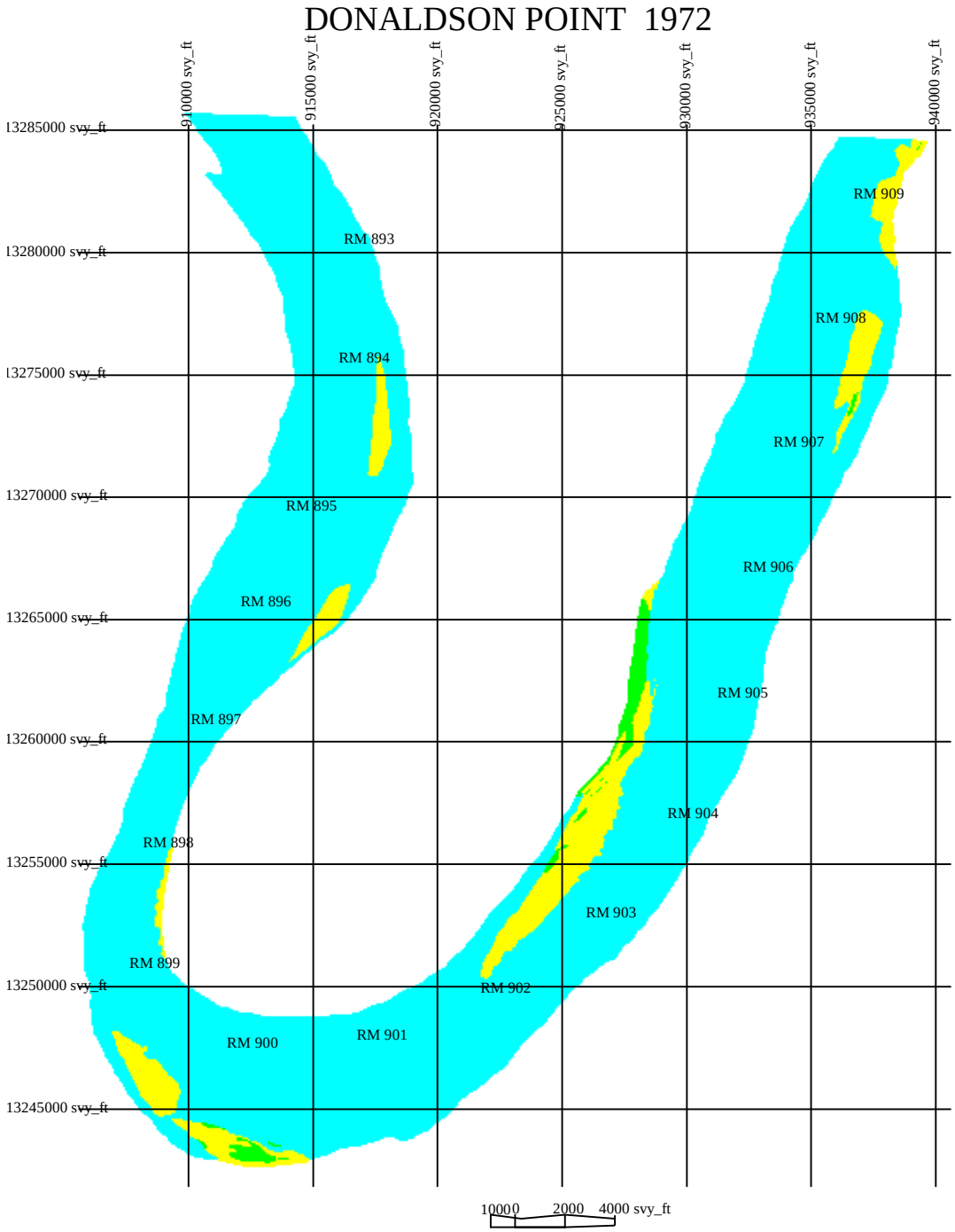

Figure C27. Sandbar vegetation, 1972, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

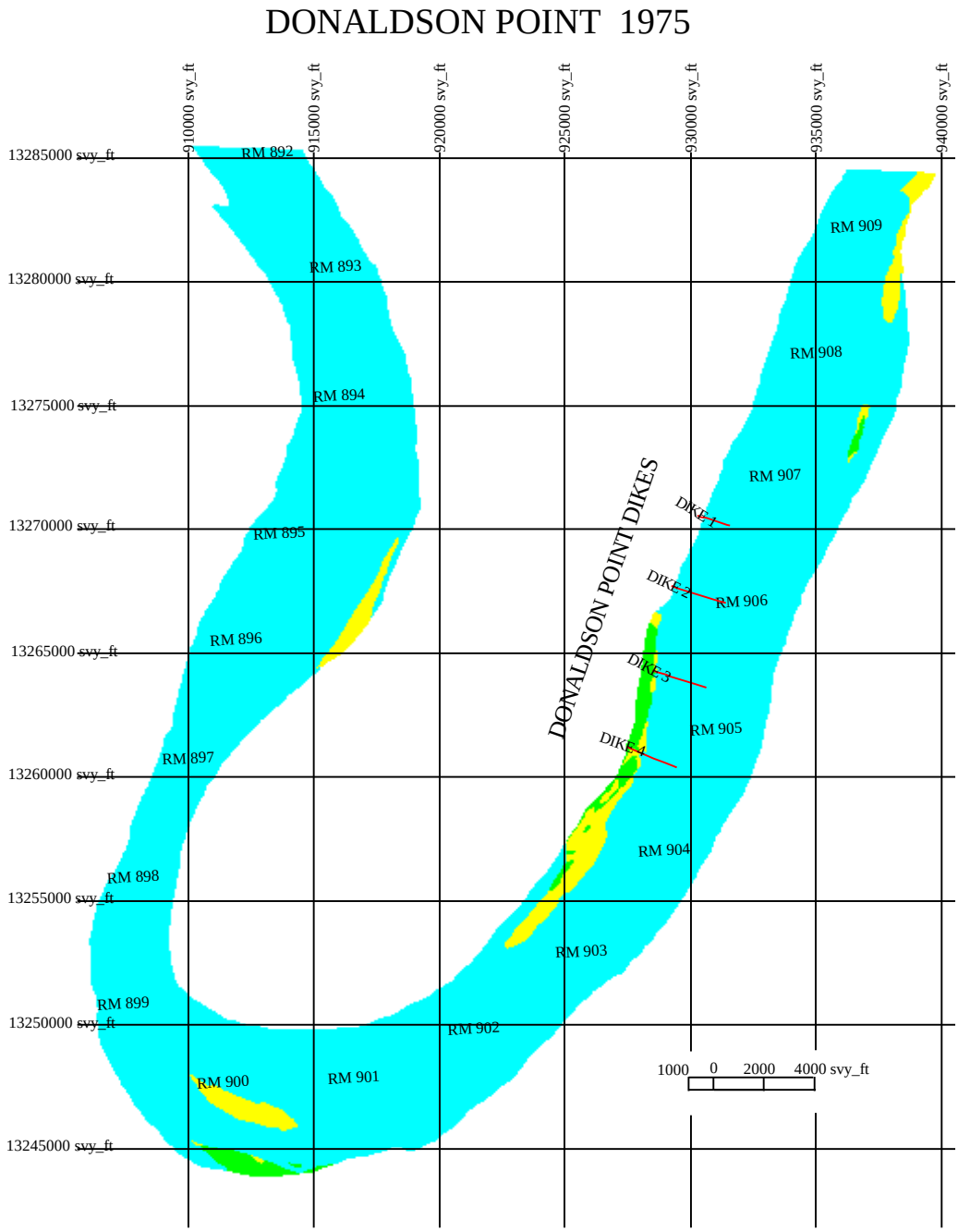

Figure C28. Sandbar vegetation, 1975, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

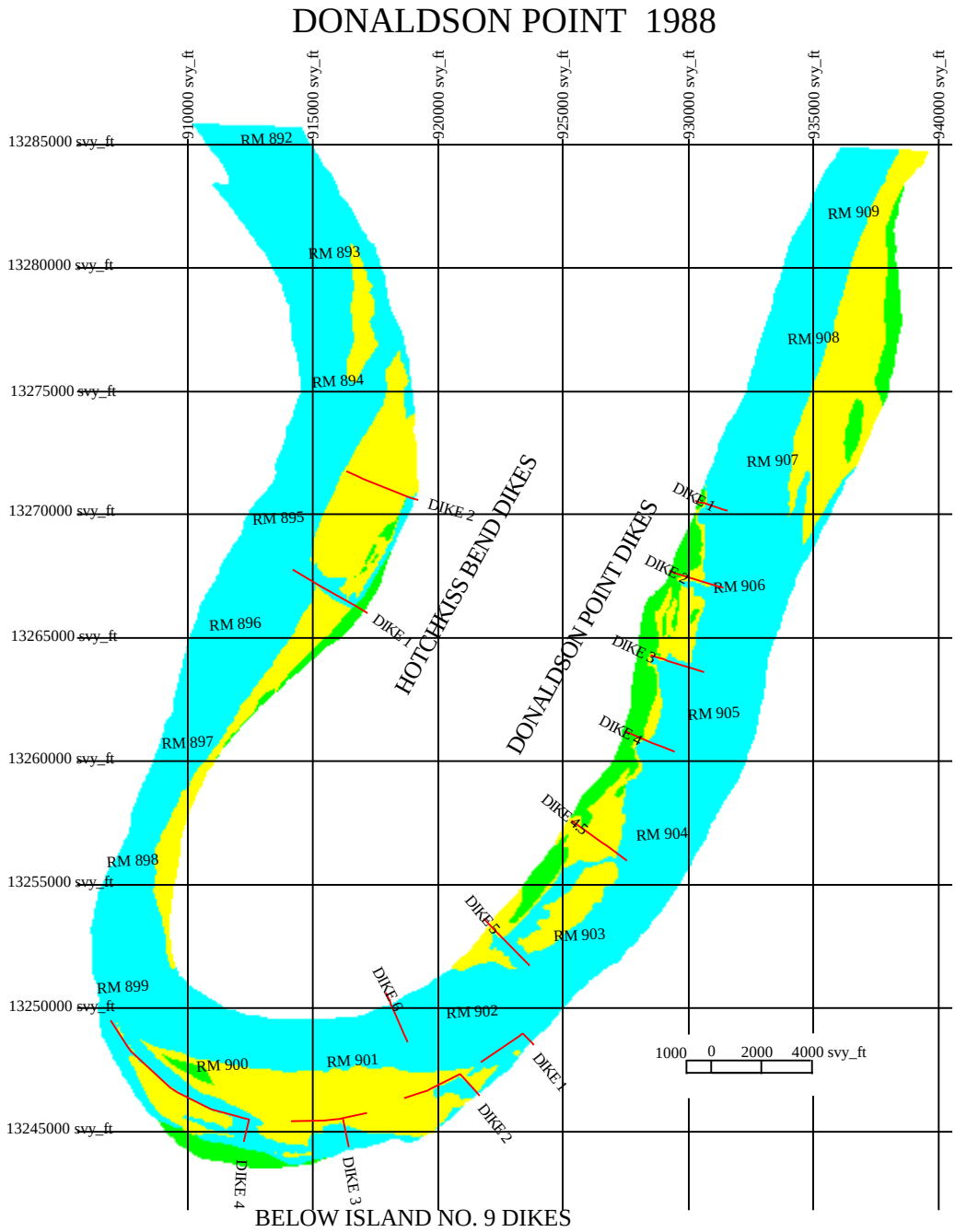

Figure C29. Sandbar vegetation, 1988, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

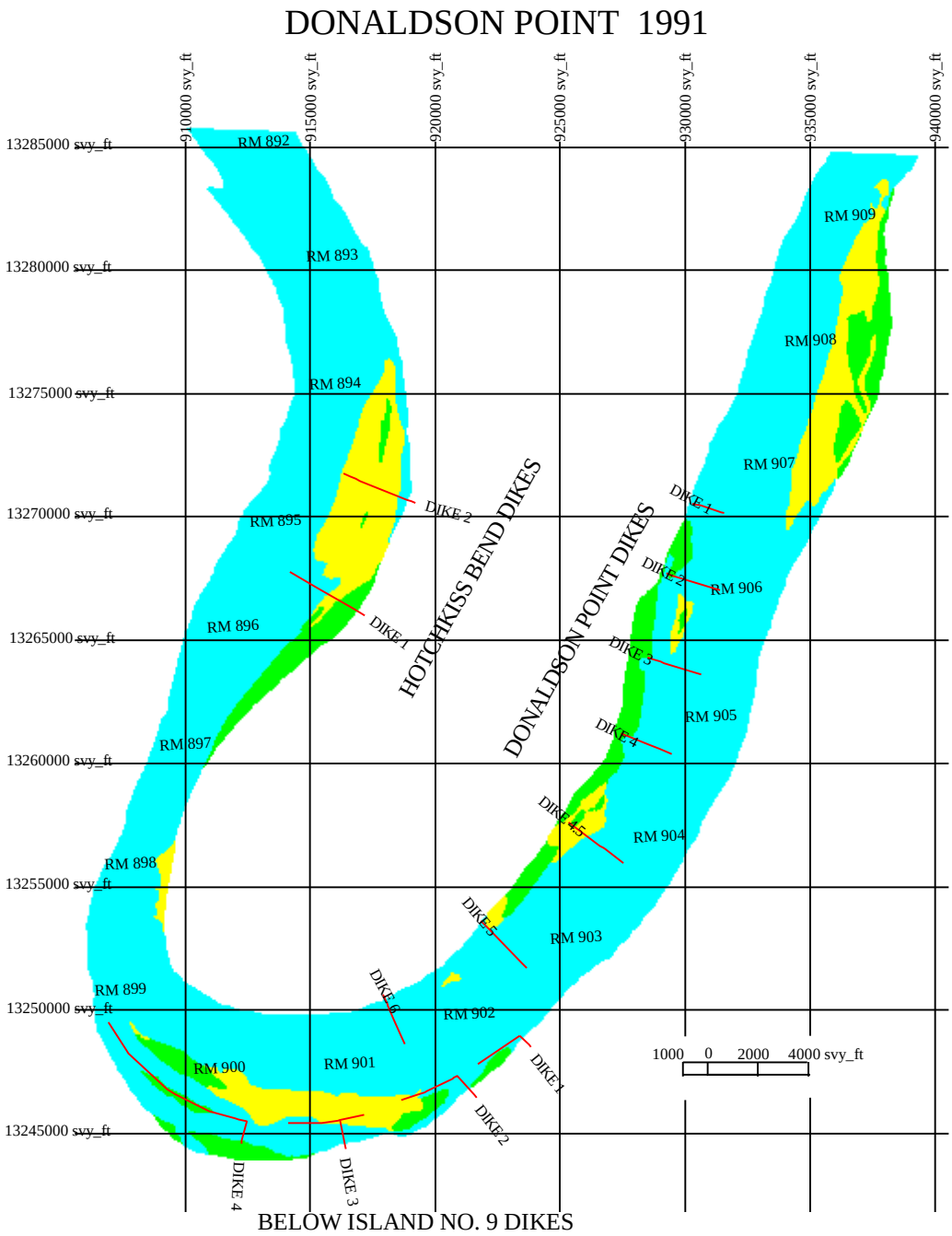

Figure C30. Sandbar vegetation, 1991, Hotchkiss Bend to Island No. 9, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

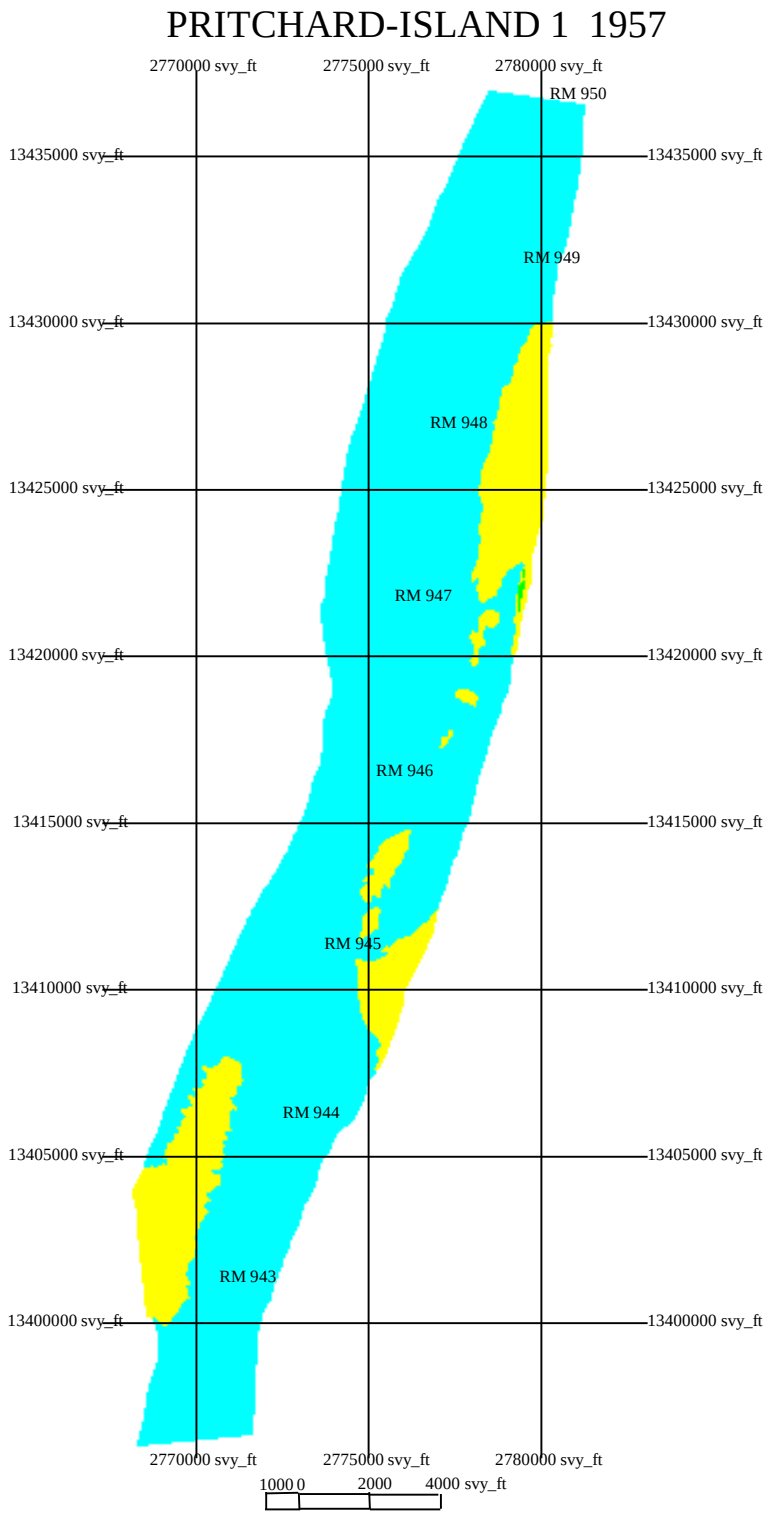

Figure C31. Sandbar vegetation, 1957, Pritchard -Island No. 1, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

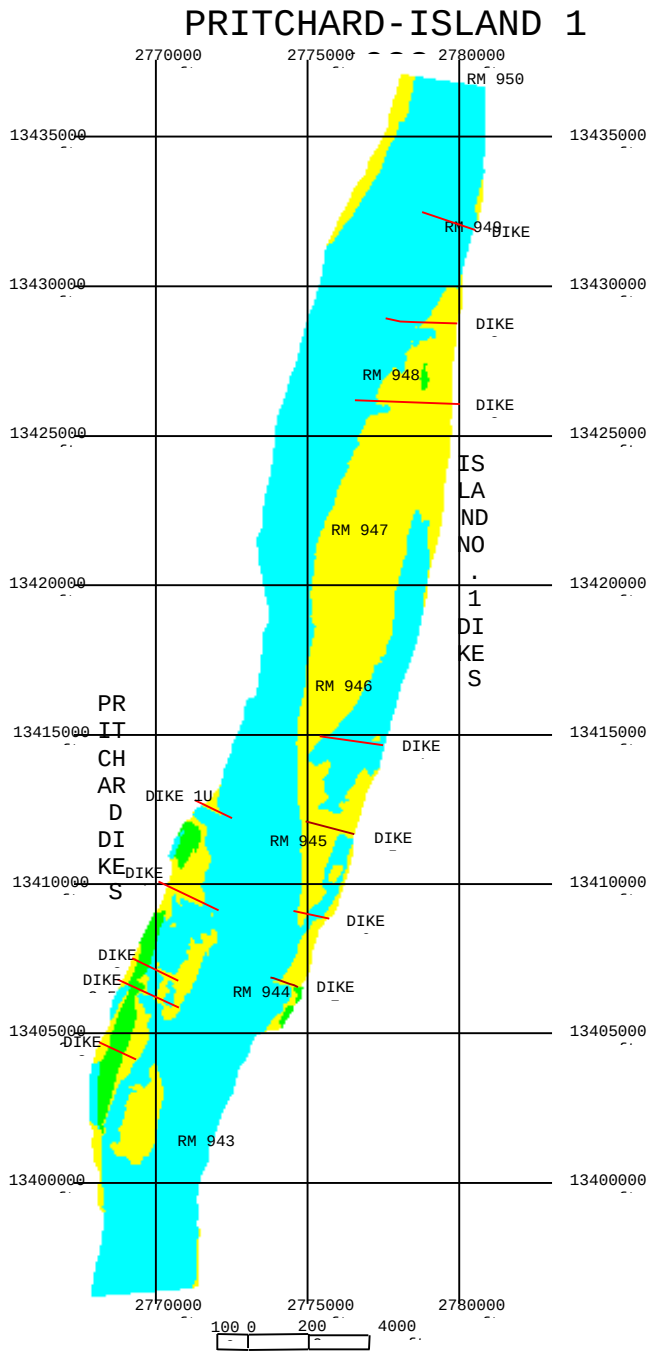

Figure C32. Sandbar vegetation, 1988, Pritchard -Island No. 1, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

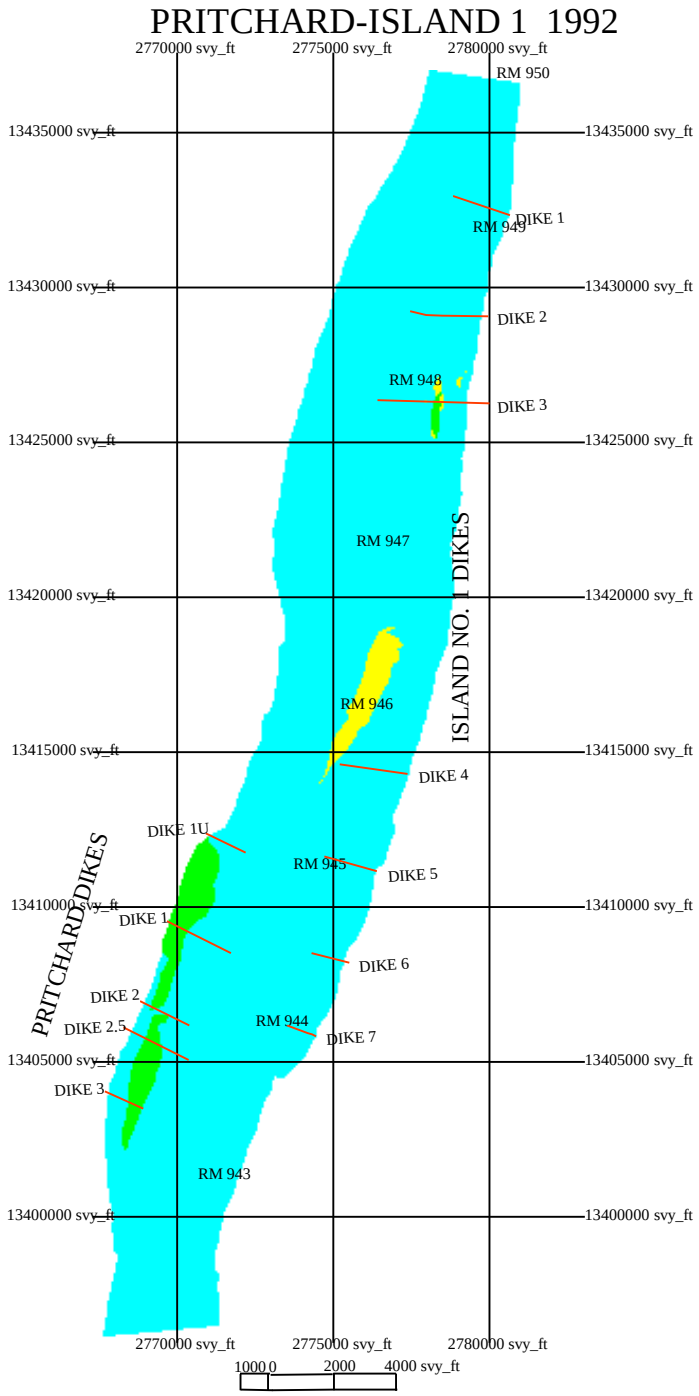

Figure C33. Sandbar vegetation, 1992, Pritchard -Island No. 1, Lower Mississippi River (yellow = bare sandbar, blue = water, green = vegetation).

Appendix D

Appendix D. STONE DIKE CONSTRUCTION HISTORY, MEMPHIS DISTRICT REACH (RM 600-954), LOWER MISSISSIPPI RIVER.

	20 RIVER MILE REACH																	
Year	605 DIKE FEET	625 DIKE FEET	665 DIKE FEET	685 DIKE FEET	705 DIKE FEET	725 DIKE FEET	745 DIKE FEET	765 DIKE FEET	785 DIKE FEET	805 DIKE FEET	825 DIKE FEET	845 DIKE FEET	865 DIKE FEET	885 DIKE FEET	905 DIKE FEET	925 DIKE FEET	945 DIKE FEET	TOTAL DIKE FEET
1960	0	6015	5600	0	0	0	0	2890	0	0	0	0	230	0	0	0	4590	19325
1961	0	0	520	0	0	0	0	2613	0	7960	0	0	0	0	0	0	0	11093
1962	7720	1070	0	0	0	0	3124	0	0	0	2497	0	280	0	0	0	0	14691
1963	1521	0	0	0	0	195	11430	0	8266	0	12797	4713	0	0	0	0	0	38922
1964	116	245	6690	0	0	11420	1855	0	0	0	0	0	0	0	0	0	0	20326
1965	0	0	0	2530	0	3750	1830	0	0	4050	0	0	0	0	0	0	0	12160
1966	0	0	5500	4795	0	8490	980	7860	0	0	0	0	0	0	0	0	0	27625
1967	0	3425	0	0	0	15105	4300	0	0	0	3860	8120	0	0	0	0	9060	43870
1968	0	2095	5730	0	5700	0	1225	0	0	8470	3493	0	6660	5250	0	0	0	38623
1969	6310	0	2200	0	0	0	4260	0	0	9127	6183	4930	0	0	0	0	0	33010
1970	0	0	1810	3380	0	0	9660	0	410	9743	81	4050	10945	0	0	0	7410	47489
1971	0	5040	3600	3470	6420	5225	0	0	0	0	2700	0	0	0	0	0	0	26455
1972	986	4190	0	3450	4920	355	779	2890	5265	0	0	6763	0	0	0	0	0	29598
1973	0	4320	0	0	0	0	380	0	0	0	0	0	0	0	8320	0	0	13020
1974	658	0	0	0	0	0	0	0	0	310	5918	7481	1415	0	0	0	0	15782
1975	0	0	9190	0	0	0	0	5950	8544	0	7322	24010	0	1070	0	0	0	56086
1976	0	0	0	0	0	0	0	0	0	140	0	3900	500	0	0	0	0	4540
1977	0	0	0	0	0	0	0	0	3210	0	0	3337	0	4936	0	0	0	11483
1978	5033	0	0	0	0	0	0	0	3030	0	0	0	0	2490	0	0	0	10553
1979	2525	4060	0	1526	0	0	0	35	0	0	55	3425	0	1340	0	0	0	12966
1980	0	0	0	12430	0	0	0	0	0	11050	0	8245	0	2784	0	0	0	34509
1981	0	0	0	0	0	0	0	0	1485	0	0	0	0	0	0	0	0	1485
1982	0	1983	0	0	0	0	0	0	2150	1099	2515	1950	0	0	0	0	0	9697
1983	0	0	0	55	0	0	0	0	10225	0	0	3257	0	0	12582	0	0	26119
1984	0	0	0	11060	0	6470	3340	0	0	0	0	10314	0	4039	12860	1150	0	49233
1985	0	0	0	0	0	3565	0	0	0	0	0	7265	0	0	0	4685	0	15515
1986	0	0	0	0	7830	0	0	0	1785	0	2130	0	0	0	0	0	0	11745
1987	0	0	0	0	1600	0	0	0	0	0	0	0	0	0	0	0	0	1600
1988	0	0	0	0	1510	0	0	0	3010	0	0	3025	0	5775	2815	0	0	16135
1989	0	5485	0	2810	0	0	0	0	0	0	2140	0	0	0	0	0	0	10435
1990	6486	0	0	0	1935	5335	0	0	4915	0	0	5900	0	0	0	0	0	24571
1991	0	4952	0	0	860	0	0	0	0	0	0	4003	0	6231	0	0	0	16046
1992	2770	0	0	0	0	0	0	7327	0	0	0	10	0	0	5300	20195	2085	37687
1993	6599	0	0	0	5300	0	0	0	0	0	0	0	0	850	12690	0	0	25439
1994	0	0	0	0	0	0	4155	8390	0	0	10080	0	0	0	1790	0	0	24415
1995	3738	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3738
TOTAL	44462	42880	40840	45506	36075	59910	47318	37955	52295	51949	61771	114698	20030	34765	56357	26030	23145	795986

Appendix D2. STONE DIKE CONSTRUCTION HISTORY, VICKSBURG DISTRICT REACH (RM 315-600), LOWER MISSISSIPPI RIVER.

20 RIVER MILE REACH

YEAR	325 DIKE FEET	345 DIKE FEET	365 DIKE FEET	385 DIKE FEET	405 DIKE FEET	425 DIKE FEET	445 DIKE FEET	465 DIKE FEET	485 DIKE FEET	505 DIKE FEET	525 DIKE FEET	545 DIKE FEET	565 DIKE FEET	585 DIKE FEET	TOTAL DIKE FEET
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	1550	0	0	0	1550
1963	0	0	0	0	0	4414	0	0	667	0	3840	6585	0	0	15506
1964	0	0	0	8030	0	0	0	0	452	0	0	0	0	0	8482
1965	0	0	0	0	0	1752	0	0	814	0	0	14834	0	6071	23471
1966	0	0	0	0	0	0	0	0	0	3720	4580	13646	0	0	21946
1967	0	0	0	0	0	1115	0	0	0	0	0	8294	0	0	9409
1968	0	0	0	0	0	0	0	0	380	7571	0	2128	10764	7921	28764
1969	0	0	0	0	0	0	0	0	1485	3592	0	3333	2281	7086	17777
1970	0	0	0	0	0	0	0	0	0	0	4725	2460	0	0	7185
1971	0	0	0	0	7960	0	0	0	282	5294	6592	5100	0	0	25228
1972	0	0	0	0	390	0	0	0	380	4320	0	0	0	0	5090
1973	0	0	3700	0	0	0	0	0	0	0	0	0	4742	2201	10643
1974	0	0	0	4421	3260	0	0	0	275	2897	0	0	548	4240	15641
1975	0	0	0	3949	418	4146	0	1910	261	0	0	0	4406	0	15090
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	6830	0	0	0	0	0	6730	0	0	0	0	13560
1978	0	0	1325	8496	0	0	5166	0	266	0	0	0	0	0	15253
1979	4306	0	2670	3270	0	4110	0	0	0	0	5278	0	0	0	19634
1980	0	0	0	0	0	0	3609	2365	161	0	0	0	0	0	6135
1981	0	0	0	0	0	0	0	0	131	0	0	0	0	3578	3709
1982	0	5351	0	0	0	4160	965	0	233	0	0	2630	0	0	13339
1983	0	0	0	0	0	0	0	3900	0	0	0	4804	0	0	8704
1984	0	0	0	0	0	0	0	1510	0	0	0	1500	0	0	3010
1985	0	0	0	0	0	1470	0	4053	0	0	0	950	0	0	6473
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	3780	0	0	0	5675	0	71	0	5300	160	0	0	14986
1988	0	0	0	2958	5380	0	0	0	219	0	5175	0	0	0	13732
1989	0	4160	0	0	3575	0	0	0	0	0	0	0	0	0	7735
1990	0	0	0	6082	0	0	0	0	132	0	9949	0	0	0	16163
1991	0	0	2823	1608	0	790	6719	2406	0	0	6482	0	0	0	20828
1992	0	6926	5186	0	0	9128	0	0	466	5243	0	0	0	0	26949
1993	0	0	0	225	0	0	0	0	0	0	0	0	0	0	225
1994	0	6334	160	6319	0	0	2148	4534	0	0	1453	0	0	0	20948
1995	0	5403	0	0	3160	17809	0	0	0	0	12735	0	4964	6978	51049
TOTAL	4306	28174	19644	52188	24143	48894	24282	20678	6675	39367	67659	66424	27705	38075	46821

APENDIX E. LEAST TERN POPULATION CENSUS DATA, AERIAL1 SURVEY METHOD

River Mile	AERIAL1 SURVEY 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	TOTAL
13	0	0	2	0	0	0	0	0	0	0	0	2
23	8	0	0	0	0	0	0	0	0	4	15	27
29	0	0	42	0	0	0	0	0	0	0	0	42
30	0	0	0	85	0	30	6	0	0	0	20	141
33	0	0	0	0	0	0	1	0	0	0	0	1
378	0	0	0	0	0	0	0	0	0	6	0	6
383	0	0	0	0	0	0	0	0	0	68	0	68
409	0	0	0	0	0	0	0	0	0	23	0	23
429	0	0	0	0	0	0	0	0	28	0	0	28
430	0	0	0	0	0	25	0	0	0	0	42	67
431	2	0	0	45	0	0	49	0	0	0	0	96
440	0	0	14	0	0	0	0	0	0	0	0	14
449	0	0	0	0	0	0	10	0	0	0	0	10
459	0	0	0	0	0	0	6	0	0	0	0	6
460	4	0	0	0	60	0	0	0	0	0	87	151
461	0	0	40	41	0	0	13	0	9	70	0	173
467	0	0	0	0	0	0	0	0	0	0	7	7
468	0	0	0	0	0	0	7	0	0	0	0	7
469	0	0	0	0	0	0	0	17	0	0	0	17
470	7	0	15	46	40	125	13	0	36	0	0	282
476	0	0	0	0	0	0	50	0	0	0	0	50
482	0	0	0	0	150	0	50	23	35	0	15	273
483	0	0	28	90	0	100	0	0	0	24	0	242
485	0	0	0	0	0	0	0	0	0	0	25	25
486	0	0	2	0	0	0	0	0	11	0	0	13
487	0	0	0	0	0	0	0	0	11	125	0	136
488	13	0	0	0	0	0	26	0	0	0	0	39
491	0	0	0	0	0	0	0	0	0	0	97	97
492	0	0	0	0	0	0	0	0	0	0	12	12
498	0	0	0	0	0	0	0	17	0	0	0	17
499	0	0	0	5	0	0	10	0	0	0	0	15
503	0	0	0	28	0	69	0	0	0	0	28	125
504	0	0	0	0	0	0	77	300	19	42	0	438
508	0	0	0	78	0	50	0	0	0	0	0	128
509	0	0	24	33	35	0	14	28	24	0	0	158
510	0	0	0	0	0	22	0	0	0	20	27	69
511	0	0	0	0	0	0	0	0	0	0	5	5
514	0	0	14	35	0	5	22	10	13	18	18	135
515	2	0	0	0	0	0	0	0	0	0	0	2
507	0	0	0	0	45	0	0	0	10	0	0	55
517	0	0	8	0	0	0	0	0	0	0	0	8
518	0	0	0	0	0	0	0	0	0	0	30	30
519	0	0	0	0	10	0	0	0	0	0	0	10
520	0	0	0	0	0	0	0	0	0	55	0	55
521	0	0	0	0	0	0	35	45	0	0	2	82
522	0	0	0	0	0	32	0	0	0	0	0	32
523	0	0	0	0	0	0	45	28	24	0	14	111
528	0	0	0	22	28	18	63	75	11	8	0	225
533	0	0	0	0	0	0	0	0	0	0	9	9
540	0	6	0	0	0	0	0	0	0	0	43	49
541	0	10	29	0	0	0	0	0	0	0	0	39
556	0	0	24	0	0	0	0	0	0	0	0	24
557	0	0	0	0	12	0	16	17	0	33	61	139
559	0	20	0	0	0	0	0	0	0	0	0	20
563	0	14	0	12	0	0	70	9	13	0	0	118
564	0	0	0	0	0	0	0	0	0	0	2	2

(Continued)

(Aerial1 Continued)

River Mile	AERIAL1 SURVEY 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	TOTAL
569	0	13	0	0	0	0	0	90	0	0	30	133
570	31	0	15	53	47	16	21	0	0	12	0	195
574	0	0	0	0	0	0	12	61	25	0	0	98
577	5	0	0	0	0	16	31	55	0	19	51	177
578	0	25	1	4	35	0	0	0	22	0	0	87
581	0	0	0	0	0	0	0	0	0	0	51	51
582	0	0	0	0	0	32	110	0	78	0	0	220
583	8	45	0	35	12	0	19	8	0	0	0	127
584	0	0	0	0	0	0	0	0	0	46	0	46
585	0	0	0	0	0	0	0	0	0	0	17	17
588	0	0	0	0	0	0	0	0	32	0	0	32
589	24	0	6	75	25	0	65	0	0	55	30	280
590	0	40	0	0	0	52	0	120	0	0	0	212
595	0	0	2	0	0	0	0	0	11	0	1	14
598	0	0	0	0	0	22	0	0	0	0	0	22
599	0	0	0	0	0	0	13	18	11	95	3	140
600	0	0	0	5	0	0	0	0	0	0	0	5
602	0	0	0	0	0	0	0	0	0	12	2	14
603	0	0	0	0	0	0	0	18	7	0	0	25
607	0	0	0	0	0	8	0	0	0	0	10	18
608	0	0	0	0	0	0	30	0	0	0	0	30
609	0	0	0	0	0	0	0	0	0	0	3	3
610	0	0	10	0	0	0	0	0	0	0	0	10
611	0	0	0	0	0	11	34	0	0	38	0	83
612	22	48	0	150	125	0	0	10	50	35	0	440
613	0	0	67	0	0	31	50	0	0	0	0	148
619	0	13	0	0	0	250	0	0	0	32	0	295
620	18	0	18	97	65	10	25	45	44	75	0	397
623	0	19	20	0	6	11	50	30	35	85	1	257
625	0	0	25	0	0	0	40	0	0	0	60	125
629	30	20	0	13	200	52	14	110	59	10	18	526
633	0	0	0	0	0	0	36	0	0	0	0	36
636	0	0	0	0	0	0	0	33	0	0	0	33
639	6	6	10	0	75	7	0	0	127	0	2	233
640	0	0	0	60	0	0	75	50	0	60	0	245
643	0	0	0	0	0	0	25	5	0	0	4	34
645	0	0	0	0	0	0	0	0	0	0	50	50
646	0	0	0	0	0	0	0	110	0	75	0	185
647	13	8	0	30	283	110	10	0	125	13	0	592
648	0	0	0	0	0	0	0	0	100	0	50	150
650	0	0	26	0	0	0	48	0	0	0	0	74
653	0	0	0	0	0	0	0	0	6	0	20	26
655	0	0	0	4	0	0	12	0	6	0	0	22
656	0	0	0	0	0	0	0	0	0	0	5	5
666	0	0	0	0	0	0	0	0	0	0	25	25
667	14	13	0	0	200	0	0	0	39	0	0	266
668	0	0	0	85	0	35	9	28	0	28	0	185
671	0	8	0	0	0	0	0	0	0	0	35	43
672	0	0	75	120	15	200	0	150	375	275	0	1210
673	0	0	0	0	0	0	110	0	0	0	0	110
675	0	0	0	0	0	0	0	0	8	0	13	21
676	6	8	3	85	35	22	0	55	0	4	0	218
679	0	0	0	0	0	0	0	0	0	11	0	11
680	0	0	0	0	0	8	2	0	0	0	2	12
681	0	0	1	45	27	0	0	6	8	0	0	87
685	0	0	0	0	0	0	0	0	0	0	2	2
686	45	0	0	0	0	0	0	14	0	0	0	59
687	0	5	0	9	25	7	5	0	21	35	0	107
689	0	0	0	0	0	0	0	0	0	0	4	4
690	0	0	0	0	0	19	0	0	0	0	0	19
691	0	15	0	0	0	0	0	0	0	0	0	15

(Continued)

(Aerial1 Continued)

River Mile	AERIAL1 SURVEY 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	TOTAL
692	51	0	0	0	0	31	0	50	50	17	0	199
693	0	0	0	77	42	0	7	25	0	0	0	151
694	0	0	9	0	0	0	0	0	20	0	0	29
697	0	0	0	0	100	0	0	0	0	0	12	112
698	0	40	0	0	0	35	50	0	0	0	0	125
699	0	0	26	0	0	50	0	200	100	225	0	601
700	0	32	0	0	200	100	0	0	100	0	24	456
701	0	0	35	0	0	0	0	0	65	10	0	110
702	0	0	0	0	75	0	0	0	0	0	0	75
703	0	0	0	0	0	0	75	0	60	65	84	284
705	0	0	80	0	0	0	0	125	0	0	0	205
706	0	40	0	0	0	180	23	0	0	0	0	243
707	0	0	0	0	0	0	0	0	0	0	3	3
709	0	0	0	0	20	0	0	0	0	0	5	25
710	18	10	0	46	0	16	0	0	0	0	0	90
711	0	0	2	0	0	0	0	0	0	0	0	2
713	0	0	0	0	11	0	0	0	0	0	0	11
715	0	0	12	0	0	0	0	0	0	0	40	52
716	0	0	0	0	0	0	23	110	115	250	0	498
719	0	0	0	0	0	0	7	0	0	0	0	7
720	0	0	0	0	0	6	0	0	0	0	30	36
721	0	0	0	0	0	0	0	0	0	15	0	15
724	60	15	0	47	40	0	0	0	0	0	0	162
725	0	0	4	0	0	25	11	0	0	12	4	56
729	0	0	0	32	0	0	0	0	0	0	1	33
730	0	0	2	0	0	0	0	0	0	0	0	2
743	0	0	0	0	0	0	0	10	0	0	0	10
745	15	0	0	23	0	0	0	0	0	0	0	38
747	0	0	0	0	0	6	0	26	0	0	14	46
754	0	0	0	0	10	104	0	225	23	0	60	422
755	0	6	2	0	0	0	20	0	0	200	0	228
757	0	0	12	0	80	0	0	0	0	0	0	92
759	0	0	15	0	90	0	0	17	12	17	0	151
760	120	8	0	150	0	26	0	0	0	0	120	424
761	0	0	0	0	0	0	0	150	0	0	0	150
764	0	0	0	0	95	3	0	9	0	0	0	107
766	0	5	0	45	0	0	8	0	11	0	10	79
771	0	0	0	0	10	0	0	103	0	100	20	233
772	0	26	40	0	0	149	110	0	41	24	0	390
774	0	0	0	0	25	0	0	0	0	0	0	25
781	0	0	0	0	100	0	0	27	0	0	0	127
782	0	55	0	85	0	0	0	0	0	9	20	169
783	30	0	0	0	0	0	42	0	0	0	0	72
785	0	0	0	0	0	0	0	0	0	0	10	10
786	0	0	31	0	0	0	0	0	0	0	0	31
787	0	0	0	0	0	0	6	0	0	0	0	6
789	0	0	0	0	0	0	0	200	75	90	2	367
790	0	0	0	0	0	85	7	18	0	53	0	163
791	0	29	0	0	0	0	0	30	22	0	0	81
792	0	0	0	23	25	0	9	0	8	55	0	120
793	0	9	5	0	25	8	0	59	15	0	0	121
794	0	0	0	0	0	65	12	24	0	0	0	101
795	26	0	0	39	0	3	0	11	0	0	0	79
797	12	0	0	0	0	0	0	0	0	0	0	12
802	0	0	0	0	0	0	0	0	0	0	3	3
803	0	11	40	0	0	0	30	0	0	0	82	163
805	0	0	0	0	0	0	0	0	0	0	3	3
806	0	0	0	0	0	0	0	0	0	0	80	80
807	160	100	0	35	500	300	24	300	0	350	0	1769
808	0	0	9	25	0	0	0	9	150	0	0	193
810	0	0	0	18	30	14	0	0	0	0	0	62

(Continued)

(Aerial1 Continued)

River Mile	AERIAL1 SURVEY 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	TOTAL
811	6	13	0	0	0	0	0	8	0	0	0	27
812	0	0	0	0	0	8	0	0	0	0	0	8
813	0	0	0	0	0	0	0	0	0	0	7	7
816	0	21	0	0	60	0	0	0	0	0	0	81
817	0	0	23	0	0	29	0	0	0	0	0	52
819	0	0	0	3	0	0	9	0	0	0	200	212
824	0	0	0	27	0	0	0	0	0	0	0	27
826	0	0	3	0	0	56	0	0	95	0	0	154
827	0	0	0	0	0	0	0	250	0	0	1	251
829	0	0	0	0	30	8	0	0	0	14	0	52
830	0	0	0	0	0	0	0	9	0	0	0	9
835	0	0	35	0	135	88	42	0	25	3	17	345
836	0	40	0	30	0	0	44	125	85	56	0	380
846	0	0	0	0	0	0	0	0	20	11	0	31
850	0	0	0	0	0	0	0	0	0	0	2	2
851	0	0	0	0	0	0	33	0	65	0	0	98
852	0	0	0	0	0	0	0	26	0	0	0	26
853	0	8	0	35	40	95	0	0	0	0	0	178
855	25	0	0	0	0	0	0	0	0	0	0	25
856	0	0	0	0	0	0	0	30	0	0	0	30
857	0	0	0	14	24	0	9	0	45	0	7	99
862	35	0	0	0	0	0	0	0	125	0	0	160
863	0	0	0	16	75	0	0	0	0	0	0	91
864	0	9	0	0	37	14	0	143	0	0	0	203
865	0	0	0	0	0	0	19	0	0	15	12	46
867	0	0	0	0	0	0	0	0	17	0	0	17
870	0	30	0	0	0	11	0	0	0	0	0	41
871	0	0	5	73	8	0	0	0	0	0	51	137
872	100	0	0	0	0	0	13	0	0	0	0	113
876	0	0	0	0	30	40	0	85	0	18	0	173
881	0	0	0	0	0	0	42	0	0	0	0	42
884	0	0	12	0	0	0	40	0	0	0	0	52
885	9	0	0	0	0	0	0	0	0	0	0	9
886	0	0	0	0	0	0	0	0	65	45	31	141
887	90	12	0	37	200	55	5	100	0	37	0	536
889	0	0	0	0	0	0	0	0	20	225	0	245
890	13	0	0	0	0	0	0	0	0	0	0	13
894	0	0	0	0	0	37	0	0	0	0	0	37
895	0	41	10	35	200	195	20	60	50	45	0	656
900	0	40	0	0	0	0	0	0	65	0	0	105
901	0	0	2	0	0	6	62	90	0	0	28	188
909	0	0	0	0	0	0	0	0	0	0	43	43
914	0	0	0	19	0	0	0	0	0	0	0	19
915	20	3	0	23	95	8	0	65	8	14	0	236
919	0	0	0	0	0	41	0	0	0	0	0	41
920	0	0	0	0	0	0	4	85	40	200	0	329
921	12	45	5	34	0	0	0	0	0	0	0	96
924	0	0	0	0	0	0	0	0	0	0	23	23
925	0	0	0	0	30	0	16	0	0	0	0	46
926	0	0	1	27	0	0	0	0	0	0	0	28
927	0	12	25	0	85	0	0	0	0	0	0	122
929	0	17	0	0	0	0	19	0	0	0	0	36
930	150	33	39	50	0	27	30	0	0	0	0	329
931	35	0	0	11	100	0	0	0	150	20	3	319
935	2	0	0	7	0	4	0	200	0	0	0	213
939	0	0	0	0	0	0	11	0	0	0	0	11
941	0	0	3	0	0	0	0	0	0	0	4	7
942	0	12	0	0	0	0	0	0	0	0	0	12
946	0	0	1	27	0	35	0	0	50	11	25	149
947	31	67	0	0	0	0	0	0	0	0	0	98
967	0	0	9	0	0	0	0	0	0	0	0	9
TOTAL	1278	1125	1018	2503	4182	3358	2311	4589	3225	3717	2129	29435

Appendix F

APENDIX F. LEAST TERN POPULATION CENSUS DATA, SMALL BOAT SURVEY METHOD

River Mile	1986	1987	1988	SMALL BOAT SURVEY 1989	1990	1991	1992	1994	1995	1997	1998	TOTAL
23	60	0	0	0	0	0	0	0	4	0	0	64
23.5	0	0	0	0	0	0	0	0	0	0	1	1
24	0	0	0	0	0	0	0	0	0	3	0	3
29	0	0	65	0	0	0	0	0	0	0	0	65
30	30	20	0	49	70	56	14	32	35	70	0	376
30.1	0	0	0	0	0	0	0	0	0	0	8	8
31	0	0	0	0	0	0	0	0	0	4	0	4
33	0	0	15	0	0	0	5	0	0	0	0	20
40	0	0	0	0	0	0	0	0	0	4	0	4
348	0	0	0	0	0	0	0	189	0	0	0	189
350	0	0	0	0	0	0	0	25	0	0	0	25
383	0	0	0	0	0	0	0	100	200	0	0	300
392	0	0	0	0	0	0	0	12	0	0	0	12
429	0	0	0	0	0	0	0	42	0	0	60	102
430	0	0	0	0	0	75	0	0	0	42	0	117
431	0	0	0	101	0	0	110	85	60	0	0	356
439.8	0	0	0	0	0	0	0	0	0	0	8	8
440	0	0	17	0	0	0	0	0	0	0	0	17
449	0	0	0	0	0	0	12	0	0	0	0	12
459	0	0	0	0	0	0	38	0	0	0	0	38
460	0	67	0	0	75	0	0	0	0	120	0	262
460.5	0	0	0	0	0	0	0	0	0	0	108	108
461	0	0	80	39	0	15	48	220	95	0	0	497
467	0	0	0	45	0	0	0	0	0	0	0	45
467.5	0	0	0	0	0	0	0	0	0	0	25	25
468	0	0	0	0	0	0	0	0	0	70	0	70
469	0	5	0	0	0	0	0	0	30	0	0	35
470	0	0	27	25	50	100	23	0	0	0	0	225
476	0	0	0	0	0	0	28	0	0	37	0	65
482	0	0	0	0	120	0	138	45	0	85	0	388
482.1	0	0	0	0	0	0	0	0	0	0	91	91
483	0	40	58	0	0	83	0	0	40	0	0	221
485	0	0	0	0	0	0	0	0	0	65	0	65
485.7	0	0	0	0	0	0	0	0	0	0	8	8
486	0	0	0	0	0	0	0	14	75	0	0	89
487	0	29	0	0	0	0	0	62	83	0	0	174
488	0	0	0	0	0	0	0	0	0	0	85	85
489	0	0	27	0	0	0	0	0	0	0	0	27
491	0	67	0	0	0	0	0	0	150	0	0	217
492	0	0	0	0	0	0	0	0	0	0	56	56
499	0	35	0	0	0	0	7	0	0	0	11	53
503	0	0	0	3	0	27	0	0	0	6	0	36
504	0	35	0	0	0	0	38	63	100	55	0	291
504.4	0	0	0	0	0	0	0	0	0	0	80	80
507	0	37	0	0	0	0	0	0	0	9	0	46
508	0	0	0	72	0	56	0	0	0	35	0	163
508.7	0	0	0	0	0	0	0	0	0	0	26	26
509	0	0	35	12	42	0	28	100	0	0	0	217
510	0	0	0	0	0	56	0	0	21	0	0	77
513.3	0	0	0	0	0	0	0	0	0	0	68	68
514	0	0	8	71	0	65	16	14	60	110	0	344
517	0	0	25	0	0	0	0	0	0	0	0	25
517.3	0	0	0	0	0	0	0	0	0	0	4	4
518	0	0	0	0	0	0	0	0	49	72	0	121
519	0	0	0	6	30	0	0	0	0	0	0	36
520	0	0	0	0	0	0	0	10	62	26	0	98

(Continued)

(Small Boat Continued)

River Mile	1986	1987	1988	1989	1990	1991	1992	1994	1995	1997	1998	TOTAL
				SMALL BOAT SURVEY								
521	0	0	0	0	0	0	31	0	0	0	0	31
522	0	0	0	0	0	65	0	0	0	0	0	65
523	0	0	0	4	0	0	52	10	0	26	0	92
528	0	0	0	15	30	14	100	100	0	0	0	259
528.5	0	0	0	0	0	0	0	0	0	0	74	74
532.5	0	0	0	0	0	0	0	0	0	0	7	7
533	0	0	0	0	0	0	0	0	0	110	0	110
535	0	0	62	0	0	0	0	0	0	0	0	62
546	0	0	20	0	0	0	0	0	0	0	0	20
557	0	0	0	0	20	0	4	0	35	61	0	120
559	0	25	0	0	0	0	0	0	0	0	0	25
559.8	0	0	0	0	0	0	0	0	0	0	38	38
562.8	0	0	0	0	0	0	0	0	0	0	19	19
563	0	25	0	0	0	0	28	25	0	12	0	90
569	0	48	0	0	0	0	0	0	0	6	0	54
569.5	0	0	0	0	0	0	0	0	0	0	70	70
570	100	0	23	21	75	43	50	12	250	0	0	574
574	0	0	0	0	0	0	10	0	0	0	14	24
577	100	0	0	0	0	53	10	0	150	0	0	313
578	0	72	0	15	75	0	0	48	0	16	0	226
579.2	0	0	0	0	0	0	0	0	0	0	35	35
582	0	0	0	0	0	58	52	12	0	0	0	122
583	30	23	14	5	70	0	86	0	0	60	0	288
584	0	0	0	0	0	0	0	0	60	0	0	60
584.3	0	0	0	0	0	0	0	0	0	0	40	40
588	0	23	0	0	0	0	0	55	0	0	0	78
589	40	0	33	23	100	0	200	0	250	21	0	667
590	0	0	0	0	0	53	0	0	0	0	0	53
594.2	0	0	0	0	0	0	0	0	0	0	30	30
595	0	0	3	0	0	0	0	19	0	0	0	22
598	0	0	0	0	0	25	0	0	0	0	0	25
599	0	0	0	0	0	0	35	0	86	0	68	189
600	0	0	0	21	0	0	0	0	0	0	0	21
603	0	0	0	0	0	0	0	0	0	0	89	89
606.4	0	0	0	0	0	0	0	0	0	0	14	14
607	0	0	0	0	0	0	0	110	0	60	0	170
608	0	0	0	0	0	0	0	0	102	0	0	102
609	0	0	0	0	0	0	0	0	0	0	40	40
611	0	0	0	0	0	8	85	0	37	9	0	139
612	250	82	0	31	75	0	0	122	30	8	150	748
613	0	0	125	0	0	17	108	0	0	0	0	250
615	0	0	0	0	0	0	0	0	0	10	0	10
615.1	0	0	0	0	0	0	0	0	0	0	8	8
619	0	18	0	0	0	400	0	45	0	0	0	463
620	35	0	73	33	75	12	37	65	150	0	0	480
621.2	0	0	0	0	0	0	0	0	0	0	83	83
623	0	47	9	0	0	42	28	65	51	0	0	242
624	0	0	0	0	0	0	0	0	0	90	0	90
625	0	0	75	0	0	0	0	0	132	0	0	207
629	50	12	6	25	300	125	28	25	10	12	0	593
629.5	0	0	0	0	0	0	0	0	0	0	34	34
632.5	0	0	0	0	0	0	0	0	0	0	16	16
633	0	0	0	0	0	0	7	0	0	0	0	7
639	50	16	38	0	76	32	0	25	0	0	0	237
640	0	0	0	29	0	0	62	0	52	0	19	162
643	0	0	0	0	0	0	62	0	0	0	0	62
643.4	0	0	0	0	0	0	0	0	0	0	35	35
644	0	0	0	0	0	14	0	0	0	0	0	14
646	0	0	0	0	0	0	0	0	230	0	0	230
647	45	92	0	17	300	79	14	43	23	13	0	626
647.6	0	0	0	0	0	0	0	0	0	0	45	45

(Continued)

(Small Boat Continued)

River Mile	SMALL BOAT SURVEY 1986	1987	1988	1989	1990	1991	1992	1994	1995	1997	1998	TOTAL
648	0	0	0	0	0	0	0	100	0	0	0	100
650	0	0	23	0	0	0	105	0	0	4	0	132
655	0	0	0	0	0	0	30	20	0	7	0	57
655.1	0	0	0	0	0	0	0	0	0	0	56	56
666	0	0	0	0	0	0	0	0	220	0	0	220
667	0	0	0	0	150	0	0	5	0	10	111	276
668	0	0	0	2	0	29	11	0	0	0	0	42
671	0	67	0	0	0	0	0	0	0	148	0	215
672	5	0	24	42	0	200	37	500	446	0	0	1254
672.5	0	0	0	0	0	0	0	0	0	0	190	190
673	0	0	0	0	0	0	150	0	0	0	0	150
675	0	0	0	0	0	0	0	5	0	0	0	5
676	8	17	27	9	40	0	0	0	0	92	0	193
676.1	0	0	0	0	0	0	0	0	0	0	28	28
679	0	0	0	0	0	0	0	0	22	0	0	22
680	0	0	0	0	0	0	19	0	0	0	14	33
681	0	0	23	0	0	0	0	12	0	0	0	35
686	45	0	0	0	0	0	0	0	0	0	0	45
687	0	20	18	18	30	4	17	0	5	40	0	152
687.8	0	0	0	0	0	0	0	0	0	0	65	65
692	80	0	0	0	0	6	0	0	6	0	0	92
693	0	0	0	17	40	0	26	0	0	0	96	179
694	14	0	0	0	0	0	0	7	0	0	0	21
697	0	0	0	0	200	0	0	0	0	38	0	238
698	0	0	0	22	0	43	65	0	0	0	290	420
699	0	0	0	0	0	30	0	12	100	3	0	145
700	0	40	0	42	0	96	18	58	0	28	0	282
701	0	0	38	47	0	0	0	13	175	0	30	303
702	0	0	0	0	0	0	0	0	6	0	0	6
703	0	0	0	0	0	0	19	175	217	156	0	567
703.6	0	0	0	0	0	0	0	0	0	0	85	85
705	0	0	64	0	0	0	0	0	0	0	0	64
706	0	50	0	0	0	75	52	0	0	0	0	177
707	0	0	0	0	0	0	0	0	0	13	0	13
707.4	0	0	0	0	0	0	0	0	0	0	4	4
709	0	0	0	0	0	0	0	0	0	12	0	12
710	3	0	0	49	0	2	0	0	0	0	0	54
715	10	15	23	0	0	0	0	0	0	0	0	48
716	0	0	0	0	0	0	45	150	265	26	0	486
716.1	0	0	0	0	0	0	0	0	0	0	264	264
717	0	0	38	0	0	0	0	0	0	0	0	38
720	0	0	0	0	0	17	0	9	0	0	0	26
721	0	0	0	0	0	0	0	0	18	0	0	18
722	0	0	0	0	0	0	0	0	0	32	0	32
724	50	38	0	49	130	0	0	0	0	0	0	267
725	0	0	26	0	0	30	17	0	23	15	0	111
725.1	0	0	0	0	0	0	0	0	0	0	10	10
729	0	0	0	0	0	0	0	0	0	3	0	3
730	0	0	8	0	0	0	0	0	0	0	0	8
740	0	0	0	0	0	0	0	0	0	0	8	8
745	45	0	0	12	0	0	0	0	0	0	0	57
746.5	0	0	0	0	0	0	0	0	0	0	11	11
747	0	47	0	0	0	8	25	24	0	0	0	104
754	0	0	0	7	115	85	0	325	0	200	0	732
754.6	0	0	0	0	0	0	0	0	0	0	261	261
755	0	75	33	0	0	0	110	0	220	0	0	438
757	0	0	0	0	0	0	8	15	0	0	0	23
759	0	0	25	0	300	0	0	10	47	42	0	424
760	70	63	0	17	0	66	50	0	0	0	0	266
760.1	0	0	0	0	0	0	0	0	0	0	127	127
761	0	0	36	0	0	0	0	0	0	0	0	36

(Continued)

(Small Boat Continued)

River Mile	SMALL BOAT SURVEY 1986	1987	1988	1989	1990	1991	1992	1994	1995	1997	1998	TOTAL
764	0	0	8	0	75	2	0	0	0	0	28	113
765	10	0	0	11	0	0	0	0	0	0	0	21
766	0	7	0	11	0	0	0	46	0	20	0	84
770.9	0	0	0	0	0	0	0	0	0	0	9	9
771	3	0	0	21	0	0	0	67	120	54	0	265
771.6	0	0	0	0	0	0	0	0	0	0	72	72
772	0	47	18	0	0	150	50	82	32	31	0	410
777	0	0	0	0	0	0	0	0	0	0	19	19
779.5	0	0	0	0	0	0	0	0	0	0	43	43
781	0	0	0	0	0	0	0	0	0	24	0	24
782	0	15	35	0	0	0	0	0	0	0	0	50
783	40	0	0	0	0	0	8	0	0	0	0	48
785	0	0	0	17	0	0	0	0	0	49	0	66
786	0	0	45	0	0	0	0	0	0	0	0	45
787	0	0	0	0	0	0	18	0	0	0	0	18
788	0	0	3	0	0	0	0	0	0	0	0	3
789	0	0	0	0	0	0	0	300	225	7	0	532
789.1	0	0	0	0	0	0	0	0	0	0	86	86
790	0	0	0	0	0	100	15	33	40	0	0	188
791	0	35	6	0	0	0	0	0	0	0	0	41
792	0	0	0	13	40	0	21	52	61	0	0	187
793	0	45	6	0	0	24	0	6	0	0	0	81
793.6	0	0	0	0	0	0	0	0	0	0	92	92
794	0	0	0	0	0	45	18	42	0	0	0	105
795	14	0	0	14	0	0	0	0	0	0	0	28
803	0	12	45	0	0	0	110	44	33	0	0	244
805.6	0	0	0	0	0	0	0	0	0	0	97	97
806	0	0	0	0	0	0	25	0	0	24	0	49
807	160	45	0	0	400	300	62	0	900	0	0	1867
807.7	0	0	0	0	0	0	0	0	0	0	297	297
808	0	0	37	60	0	0	0	750	0	0	0	847
810.3	0	0	0	0	0	0	0	0	0	0	40	40
811	30	15	23	0	0	0	0	15	0	0	0	83
815	0	0	0	0	0	0	0	0	0	0	6	6
816	0	8	0	0	150	0	16	0	0	0	0	174
817	15	0	0	0	0	45	0	0	0	0	0	60
818.9	0	0	0	0	0	0	0	0	0	0	228	228
819	0	0	0	15	0	0	0	80	0	120	0	215
820	0	12	0	0	0	0	0	0	0	0	0	12
824	0	0	0	19	0	0	0	0	0	0	0	19
825	0	0	0	0	0	0	14	0	0	18	0	32
825.2	0	0	0	0	0	0	0	0	0	0	52	52
826	0	0	23	0	0	66	0	250	0	0	0	339
827	0	20	48	0	0	0	0	0	28	0	0	96
828	0	0	0	0	0	0	0	0	0	0	63	63
829	0	50	3	20	0	12	0	0	35	0	0	120
830	6	0	0	0	0	0	0	0	0	0	0	6
835	0	0	50	0	300	275	31	15	45	50	0	766
835.5	0	0	0	0	0	0	0	0	0	0	94	94
836	0	50	0	73	0	0	72	175	120	0	0	490
837	0	0	24	0	0	0	0	0	0	0	0	24
844	0	0	0	112	0	0	0	0	0	0	0	112
846	0	0	0	0	0	0	0	15	23	0	0	38
849	0	0	0	0	0	0	0	0	0	123	0	123
850	0	0	8	0	0	0	0	0	0	42	0	50
851	0	0	0	0	0	0	200	125	43	0	21	389
851.5	0	0	0	0	0	0	0	0	0	0	9	9
852	0	0	19	0	0	0	0	0	0	0	0	19
853	0	90	0	35	200	4	0	0	0	0	0	329
855	10	0	0	0	0	0	0	0	0	0	0	10
857	0	45	0	8	0	60	27	123	31	3	51	348

(Continued)

(Small Boat Continued)

River Mile	SMALL BOAT SURVEY 1986	1987	1988	1989	1990	1991	1992	1994	1995	1997	1998	TOTAL
858	0	0	30	0	0	0	0	0	0	0	0	30
862	75	0	68	11	0	0	0	400	0	0	0	554
863	0	0	0	7	180	0	0	0	0	0	0	187
864	0	75	0	0	0	65	0	0	0	27	0	167
865	0	0	18	0	0	0	34	0	21	0	0	73
865.1	0	0	0	0	0	0	0	0	0	0	251	251
870	0	60	0	0	0	14	36	0	0	0	0	110
871	0	0	29	25	40	0	0	0	0	6	0	100
871.1	0	0	0	0	0	0	0	0	0	0	77	77
872	100	35	6	0	0	0	24	57	0	0	0	222
876	0	0	0	46	0	44	34	0	0	0	0	124
876.2	0	0	0	0	0	0	0	0	0	0	10	10
881	0	0	65	0	0	0	0	0	0	0	0	65
884	0	45	38	0	0	0	34	90	0	77	88	372
884.4	0	0	0	0	0	0	0	0	0	0	40	40
885	0	0	0	0	0	0	0	0	16	0	0	16
886	30	0	0	0	0	28	0	60	32	0	0	150
887	15	40	33	12	300	56	0	0	33	175	0	664
887.1	0	0	0	0	0	0	0	0	0	0	72	72
888	0	0	0	0	0	0	0	70	0	0	0	70
889	0	0	0	0	0	0	0	76	200	0	0	276
890	14	0	0	0	0	0	0	0	0	0	0	14
894	0	0	0	0	0	50	0	0	0	0	0	50
895	0	80	22	6	500	200	65	40	54	35	0	1002
895.1	0	0	0	0	0	0	0	0	0	0	156	156
900	0	70	48	0	0	0	0	60	0	23	0	201
900.8	0	0	0	0	0	0	0	0	0	0	17	17
901	0	0	23	0	0	26	62	0	9	0	0	120
908	0	0	0	0	65	0	17	0	0	28	0	110
913.5	0	0	0	0	0	0	0	0	0	0	16	16
914	0	0	0	7	0	0	0	0	0	0	0	7
914.9	0	0	0	0	0	0	0	0	0	0	7	7
915	7	0	0	6	0	23	0	0	24	0	23	83
916	0	0	0	0	0	0	0	0	0	0	6	6
919	0	0	0	0	0	85	0	0	0	0	0	85
920	0	0	17	0	0	0	25	175	220	0	0	437
921	50	100	17	270	0	0	0	0	0	0	0	437
922	0	0	0	0	0	0	0	0	0	0	2	2
923	0	0	0	0	0	0	0	0	0	0	8	8
924	0	0	0	0	0	0	0	0	0	24	0	24
925	0	0	0	0	0	38	12	0	0	0	0	50
926	0	0	15	9	0	0	0	0	0	0	5	29
927	0	30	78	0	110	0	0	0	0	70	0	288
927.8	0	0	0	0	0	0	0	0	0	0	37	37
928	0	0	0	0	0	0	0	0	62	0	0	62
929	0	25	0	0	0	0	27	0	0	0	0	52
930	200	115	65	21	0	36	83	0	0	0	0	520
931	9	0	58	34	90	200	0	200	0	20	0	611
931.1	0	0	0	0	0	0	0	0	0	0	66	66
934.5	0	0	0	0	0	0	0	0	0	0	13	13
935	0	0	0	38	0	10	0	5	0	0	0	53
939	0	0	0	0	0	0	0	0	0	0	4	4
940	0	0	0	0	0	0	0	0	0	52	0	52
940.1	0	0	0	0	0	0	0	0	0	0	21	21
941	0	0	42	0	0	0	0	0	0	0	0	42
945	0	0	0	0	0	0	0	0	0	130	0	130
946	0	0	39	26	0	75	115	43	82	0	0	380
947	200	100	0	0	0	0	0	0	0	0	0	300
948	0	0	0	63	0	0	0	0	0	0	0	63
TOTAL	2108	2521	2356	2005	5038	4297	3653	6730	6971	3428	5443	44550

Appendix G

Statistical Modeling of Interior Least Tern populations in upper reaches of the Lower Mississippi River from Cairo (IL) to Greenville (MS)

Francisco J. Vilella, Ph.D.

Final Report

Mississippi Cooperative Fish and Wildlife Research Unit
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Department of Wildlife and Fisheries
Mississippi State University
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Introduction

Since 1984, the U.S. Army Corps of Engineers (COE) has been conducting annual surveys of the endangered Interior Least Tern Sterna antillarum athalassos (ILT) along 1100 kilometers of the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi (Rumancik 1994). Since 1995 we have been developing statistical models to examine survey methodologies, and ILT population parameters and trends, from survey data collected between 1984-1995 (Vilella 1996).

In this report we present results from statistical models of ILT population data collected through 1995 in the upper reaches of the Lower Mississippi River (LMR) from Cairo, Illinois (UR30), to Greenville, Mississippi (RM540). We examined temporal trends in ILT populations as determined by aerial and small boat surveys conducted between 1986-1995. Various statistical models were utilized to examine ILT populations and temporal trends.

The analysis was based on data obtained by SMALL BOAT and AERIAL1 methods. These were utilized as other methods (TOWBOAT and AERIAL2) were found to be unreliable (see Vilella 1996 for analysis of survey methods). As the entire lower Mississippi River was surveyed every year from Cape Girardeau, Missouri, to Vicksburg, Mississippi, there was no sampling error associated with data collection. However, while no sampling error was associated with the surveys, measurement error (i.e., under or overestimating ILT numbers) was a major factor that always influences surveys of dynamic populations (Pollock and Kendall 1987). To address this, we characterized ILT populations for any given year using the distribution of the number of birds per river mile.

Methodology

Modeling Effort

Statistical analyses were conducted using the Statistical Analysis System (SAS 1988). We utilized results of aerial and small boat surveys. We did not include 1993 in the analysis as only aerial surveys were conducted.

Frequently, one attempts to model count data using the Poisson distribution (Barron 1992). The Poisson distribution has the well known property that its mean is equal to its variance.

$$P(Y = y) = \frac{\exp(-l)\ l^{y}}{y!} \quad y = 0,1,\ldots,\infty.$$

Previous modeling attempts (Vilella 1996) determined this condition was not met by the data since the wide range of counts (i.e., 0 to 500) resulted in the variability of counts being much larger than mean number of birds per river mile. Thus, it was unlikely we could model the distribution of ILT per river mile in the upper LMR using the standard Poisson distribution.

The simple Poisson model assumes that the intensity parameter lambda (?) is fixed and constant across river miles. This assumption is often not met for biological populations as ecological factors such as resource availability (i.e., sandbar habitat, forage fish) vary across space and time (Wiens 1976). Therefore, a reasonable next step in modeling was to allow the intensity parameter to vary randomly. Within the Poisson scheme, if the intensity parameter varies randomly according to a gamma distribution with scale parameter (r) and dispersion parameter beta (ß), the distribution of counts should follow a negative binomial distribution. That is:

$$Prob(Y = y) = \binom{r + y - 1}{r - 1} p^{y} (1 - p)^{r} \quad y = 0,1,\ldots,\infty \quad where \quad p = b/b + 1$$

Previous modeling efforts (Vilella 1996) indicated some river miles contained very large numbers of birds ($ 500 ILT), some river miles contained very small numbers (# 50 ILT), and many river miles were unoccupied (0 ILT). In view of this, we assumed the sampled population of river miles consisted of three sub-populations. We next modeled the distribution of ILT numbers per river mile with a mixture of Poisson distributions:

$$Prob(Y = y) = q + (1 - q)(pe^{-l_1} + (1 - p)e^{-l_2})) \; if \;\; y = 0$$

$$Prob(Y = y) = (1 - q)(p\frac{e^{-l_1} l_1^y}{y!} + (1 - p)\frac{e^{-l_2} l_2^y}{y!}) \; if \;\; y > 0$$

Frequently, the concept of Amixing@ has a simple and direct interpretation in terms of the situation under investigation (Barron 1992). In our case, the probability model of the number of terns per river mile is given by; theta (?) representing the proportion of river miles with no observed terns; p constituting a mixing parameter which yields relative proportion of river miles with small colonies of terns. Lambda 1 ($?_1$) and Lambda 2 ($?_2$) are model parameters for subpopulations (i.e., average ILT/river mile) in small and large colonies, respectively.

Modeling results were evaluated using a test for goodness of fit (Conover 1980), where a random sample from the three proposed models is examined in order to test the null hypothesis that the unknown distribution function is in fact a known, specified function. In other words, the smaller the difference, the better the fit. The test statistic (Kolmogorov-Smirnov) computes differences between the empirical distribution and the hypothesized distribution functions and has the form,

$$T = Supremum \;\; |F(y) - S(y)|,$$

where S(y) is the empirical cumulative distribution and F(y) represents the hypothesized cumulative distribution evaluated at y. Quantiles are generally available for use in two-sided test at a=.20,.10,.05,.02. The tables are exact for n#20. Estimation for n>40 is based on the asymptotic distribution of test statistic T.

Trend Analysis

Next, we studied the temporal trends of total estimated numbers (calculated from the mixed Poisson model) to assess the trend across years for ILT populations. This observed trend was quantified by regressing total number of birds as the response variable and year as the independent variable using Poisson regression (PROC GENMOD SAS 1988), while allowing for overdispersion with a linear link function (Lawless 1987).

RESULTS

The empirical distributions of ILT numbers per river mile are given in Table G1.1 (Aerial 1) and Table G2.1 (Small Boat). Results indicated the Poisson distribution was inadequate to model ILT numbers per river mile (P < 0.01) for all years and both survey methods (Tables G1.2 and G2.2). The flexibility allowed by the negative binomial distribution did not sufficiently improve the model; it was also inadequate to fit the distribution of ILT numbers per river mile (P < 0.01) in all years except 1986 for both survey methods (Tables G1.3 and G2.3).

Nevertheless, results of the mixed Poisson model (Tables G1.4 and G2.4) suggested it was acceptable for modeling the distribution of ILT per river mile (P > 0.15) for all years and both survey methods.

Estimation of Model Parameters

Estimating intensity parameters for all three models examined was carried out using the method of moments (PROC NLIN SAS 1988). Parameter estimates and standard errors for the Poisson model are presented in Table G1.2 and Table G2.2. Parameter estimates and standard errors for the negative binomial model are reported in Table G1.3 and Table G2.3. Similarly, we estimated mixed Poisson model parameters and their standard errors using method of moments. The method of moments fits the empirical distribution function (EDF) of the number of birds per river mile (i.e., observed ILT) against the theoretical distribution function (TDF) according to the particular model. A fitted plot of EDF and TDF for the 1995 small boat surveys is given in Figure G1. For the mixed Poisson model the TDF is:

$$P(Y \le y) = \sum_{i=0}^{y} Prob(Y = i) = q + (1-q)\left(p \sum_{i=0}^{y} \frac{e^{-l_1} l_1^i}{i!} + (1-p) \sum_{i=0}^{y} \frac{e^{-l_2} l_2^i}{i!}\right)$$

The resulting estimates and standard errors for the mixed Poisson model are given in Table G1.4 and Table G2.4.

Estimated total number of birds

As the mixed Poisson model adequately described distribution of ILT in the LMR region of interest (UR30-RM540), once the parameters are estimated, we calculated the total number of birds based on the fitted model. Table G3 contains the estimated ILT totals for the two methods across years.

It is noteworthy to mention Aerial 1 method consistently (except for 1989) provided a smaller estimated number of birds compared to Small Boat method. A plot of these estimated totals is presented in Figure G2. This may partly due to the documented lower accuracy of aerial surveys (Caughley et al. 1976).

Trend Analysis

A visual examination of Figure G2 indicates Interior Least Tern populations in the upper reaches of the LMR showed a positive trend over time. An unusually large number of birds were observed in 1990, which may merit further investigation. Results of Poisson regression analysis verified Interior Least Tern populations have exhibited a positive trend in the LMR region studied (UR30-RM540) from 1986-1995 (P = 0.02 small boat survey, P = 0.04 aerial survey).

DISCUSSION

As with previous modeling attempts (Vilella 1996), these statistical models are only a first approximation to explaining the distribution of ILT on the LMR. The fact that the Poisson mixture model performed better suggests a high degree of heterogeneity exists with respect to presence of least terns in the LMR. Thus, ILT presence is not due to purely random factors.

It is important to mention the purpose of these modeling efforts was mostly descriptive in nature. We needed to identify which known distribution best fitted the empirical data. Given the limitation of the data, consisting solely of numerical observations and river mile locations, there is little predictability associated with these models. For example, the estimated ILT totals generated from the Poisson mixture model are meant to be used to verify the empirical observation that tern populations were exhibiting a positive trend over time. The model was not meant to predict totals that are exactly like, or very similar, to the observed number of terns. This is likely a result of high measurement error in the surveys and low frequency of colonies with very large tern numbers. Developing ILT models with higher predictability will require incorporating population (e.g., productivity), and ecological parameters (i.e., habitat selection) into the model. This was not

possible when count data and location were the only available parameters.

Therefore, further research is needed to elucidate the deterministic components of the model, since exogenous variables likely affecting the presence of birds in different locations of the river are presently unknown. In other words, the current Poisson mixture model can characterize LMR least tern populations in terms of their numerical distributions (i.e., small and large groups), yet, it cannot explain why a particular site in the river has more or less terns from one year to the next, or between different sites in the river within a year.

Similarly, there is a need to address the functional values of interior least tern habitat in the LMR, to better understand why so much of the river=s sandbar habitat is apparently not being utilized, and how important are those sandbars currently in use. In areas of the Platte River, ILT did not exhibit marked selection for sites with distinct sets of habitat features nor did they occupy most of the apparently available habitat (Kirsch 1996). What constitutes quality habitat for least terns in the LMR must be quantitatively determined in order to detect changes which may be reducing area of quality habitat throughout the LMR or degrading the quality of existing sites.

Poisson regression of aerial and small boat surveys indicated that while there is a significant positive trend, cyclical effects may be present. Natural populations are usually characterized by cyclic demographic events. Elucidating the mechanisms that regulate and limit least tern populations in the LMR will provide means to verify and explain the observed population trends.

Many colonial waterbird species have evolved life history strategies resulting from a combination of patchily distributed suitable predator-and-disturbance-free colony sites used for nesting and rearing young, and, patchily distributed foraging areas. I propose least terns in the LMR should be similarly viewed as consisting of one or several metapopulations, whose dynamics may be determined not only by within-patch (i.e., colony) birth and death processes, but also by between patch movement of individuals (Spendelow and Nichols et al. 1995).

The persistence of viable interior least tern populations in the LMR will require understanding how they operate within the central theme of metapopulation theory (Wiens 1996). In other words, how do these partially isolated subpopulations persist in the presence of stochastic events (i.e., random river stage fluctuations) that operate at the level of the individual colony? I recommend cooperative research efforts will be required to elucidate patterns and processes that are presently operating and may be determining survival and persistence interior least terns in the LMR.

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Table G1.1 The distribution of the number of birds per river mile (aerial1 method).

Frequency	1986	1987	1988	1989	1990
0	425	411	412	412	411
1 –25	20	32	35	17	15
26 – 50	8	14	10	18	12
51 – 75	2	2	2	4	5
76 – 100	2	1	1	6	8
101 – 200	3	0	0	3	7
201 – 300	0	0	0	0	1
301 – 400	0	0	0	0	0
401 – 500	0	0	0	0	1
Above 500	0	0	0	0	0
Total	460	460	460	460	460

Frequency	1991	1992	1993	1994	1995
0	402	397		406	408
1 –25	27	38		22	21
26 – 50	14	17		11	12
51 – 75	5	5		7	8
76 – 100	4	0		7	4
101 – 200	6	3		6	2
201 – 300	2	0		0	4
301 – 400	0	0		1	1
401 – 500	0	0		0	0
Above 500	0	0		1	1
Total	460	460		460	460

Table G2.1 The distribution of the number of birds per river mile (small boat method).

Frequency	1986	1987	1988	1989	1990
0	420	410	397	407	428
1 –25	15	19	32	34	1
26 – 50	14	17	21	14	5
51 – 75	3	7	8	3	5
76 – 100	4	6	1	0	3
101 – 200	3	1	1	1	8
201 – 300	1	0	0	1	5
301 – 400	0	0	0	0	1
401 – 500	0	0	0	0	1
Above 500	0	0	0	0	0
Total	460	460	460	460	460

Frequency	1991	1992	1993	1994	1995
0	404	393		398	404
1 –25	17	27		21	14
26 – 50	15	20		10	15
51 – 75	11	10		11	6
76 – 100	5	3		5	3
101 – 200	5	7		9	8
201 – 300	2	0		2	8
301 – 400	1	0		2	0
401 – 500	0	0		1	1
Above 500	0	0		1	1
Total	460	460		460	460

Table G1.2 The Poisson Model (aerial1 method).

	1986	1987	1988	1989	1990
lambda	2.7174	2.4457	1.8978	4.52174	8.29130
s.e. of lambda	0.07686	0.07292	0.06423	0.06423	0.13426
Test Stat	0.85787	0.80681	0.74575	0.88478	0.89323
p-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

	1991	1992	1993	1994	1995
lambda	6.33043	3.95870		6.67826	7.19565
s.e. of lambda	0.11731	0.09277		0.12049	0.12507
Test Stat	0.87259	0.84396		0.88135	0.94558
p-value	< 0.01	< 0.01		< 0.01	< 0.01

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G2.2 Summary statistics of the Poisson Model for small boat.

	1986	1987	1988	1989	1990
lambda	4.5826	4.7957	4.3848	3.5043	10.1978
s.e. of lambda	0.09981	0.10210	0.09763	0.08728	0.14889
Test Stat	0.902820	0.883040	0.850580	0.854710	0.930400
p-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

	1991	1992	1993	1994	1995
lambda	8.1326	6.4870		12.3587	12.4239
s.e. of lambda	0.13296	0.11875		0.16391	0.16434
Test Stat	0.877970	0.852820		0.865210	0.878260
p-value	< 0.01	< 0.01		< 0.01	< 0.01

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G1.3 The negative binomial model (aerial1 method).

	1986	1987	1988	1989	1990
P	0.012938	1.027671	0.027538	0.014782	0.005881
s.e. of p	0.005589	0.008626	0.009720	0.004674	0.002177
r	0.035619	0.069600	0.53743	0.067843	0.49048
s.e. or r	0.013428	0.020128	0.016992	0.020081	0.16433
Test Stat	0.067342	0.114430	0.071207	0.144320	0.116170
p-value	.15>p>.2	<0.01	<0.01	<0.01	<0.01

	1991	1992	1993	1994	1995
P	0.008060	0.020833		0.008964	0.011234
s.e. of p	0.002915	0.005938		0.002999	0.003252
r	0.051437	0.084227		0.060407	0.081757
s.e. or r	0.016891	0.023178		0.018713	0.022950
Test Stat	0.093529	0.141280		0.130440	0.253520
p-value	<0.01	<0.01		<0.01	<0.01

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G2.3 Summary statistics of the negative binomial model for small boat.

	1986	1987	1988	1989	1990
P	0.008963	0.017684	0.022750	0.013040	0.004312
s.e. of p	0.0035988	0.0049845	0.0059216	0.0049585	0.001680
r	0.014150	0.086330	0.102080	0.046300	0.044160
s.e. of r	0.014766	0.023684	0.026672	0.015729	0.015425
Test Stat	0.090556	0.185450	0.183400	0.066813	0.144210
p-value	<0.01	<0.01	<0.01	.05<P<.02	<0.01

	1991	1992	1993	1994	1995
P	0.006649	0.013220		0.003853	0.003523
s.e. of p	0.0023402	0.0037171		0.0014448	0.001376
r	0.054440	0.086910		0.047800	0.043930
s.e. or r	0.017539	0.023927		0.016207	0.015389
Test Stat	0.117110	0.167730		0.098560	0.098007
p-value	<0.01	<0.01		<0.01	<0.01

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G1.4 The mixed poisson model (aerial1 method).

	1986	1987	1988	1989	1990
lambda 1	8.91	7.76	4.8	18.35	29.5
s.e. of lambda 1	1.04	0.67	0.52	1.42	1.42
lambda 2	31.9	33.09	28.7	50.7	184.4
s.e. of lambda 2	1.6	1.02	0.95	2.09	11.06
theta	0.92	0.89	0.9	0.9	0.90
s.e. of theta	0.0042	0.006	0.005	0.004	0.004
P	0.47	0.63	0.55	0.47	0.58
s.e. of p	0.041	0.033	0.034	0.04	0.701
Test Stat	0.014750	0.024429	0.15524	0.021672	0.026779
p-value	> .2	> .2	> .2	> .2	> .2

	1991	1992	1993	1994	1995
lambda 1	10.1	10.82		7.4647	10.5990
s.e. of lambda 1	0.95	0.59		0.9942	0.8730
lambda 2	55.1	39.6		63.9120	190.9813
s.e. of lambda 2	1.76	1.07		2.3821	7.8268
theta	0.87	0.86		0.88	0.88
s.e. of theta	0.007	0.004		0.01230	0.01145
P	0.55	0.55		0.5547	0.7456
s.e. of p	0.033	0.03		0.0513	0.0358
Test Stat	0.023909	0.01657		0.039461	0.066329
p-value	> .2	> .2		> .2	.15<p<.2

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G2.4 The mixed poisson model (small boat method).

	1986	1987	1988	1989	1990
lambda 1	11.092	19.8857	18.0484	12.712	70.7702
s.e. of lambda 1	0.99671	1.07314	0.88618	0.67262	1.93871
lambda 2	73.2074	67.6453	43.1168	38.9891	284.216
s.e. of lambda 2	2.2778	1.60051	1.26101	1.09714	9.19183
theta	0.91	0.89	0.86	0.88	0.93
s.e. of theta	0.0043	0.0045	0.0048	0.0040	0.0030
P	0.579	0.548	0.559	0.594	0.628
s.e. of p	0.0391	0.0324	0.0334	0.0276	0.0338
Test Stat	0.013878	0.018525	0.025784	0.015531	0.013476
p-value	> .20	> .20	> .20	> .20	> .20

	1991	1992	1993	1994	1995
lambda 1	25.7249	17.4407		20.4579	30.6395
s.e. of lambda 1	1.18323	0.82387		1.72417	1.14878
lambda 2	75.0189	58.9959		82.8854	148.7013
s.e. of lambda 2	2.61882	1.70291		3.14113	4.82314
theta	0.88	0.85		0.87	.88
s.e. of theta	0.0041	0.0047		0.0053	0.0037
P	0.540	0.544		0.480	0.587
s.e. of p	0.331	0.0264		0.0338	0.0279
Test Stat	0.25728	0.020871		0.030620	0.023130
p-value	> .2	> .2		> .2	.15<p<.2

Row Information

* Estimated parameter value
* Standard error of estimated parameter value
* Kolmogorov-Smirnov test statistic value
* Associated p-value for goodness of fit

Table G3. Total number of Interior Least Terns estimated using the Pois son mixtures model for aerial1 and small boat methods, 1986-1995.

YEAR	SMALL BOAT	AERIAL 1
1986	1542	776
1987	2099	867
1988	1874	716
1989	1290	1632
1990	4836	4350
1991	2672	1814
1992	2511	1531
1993	----	----
1994	3165	1800
1995	4383	3127

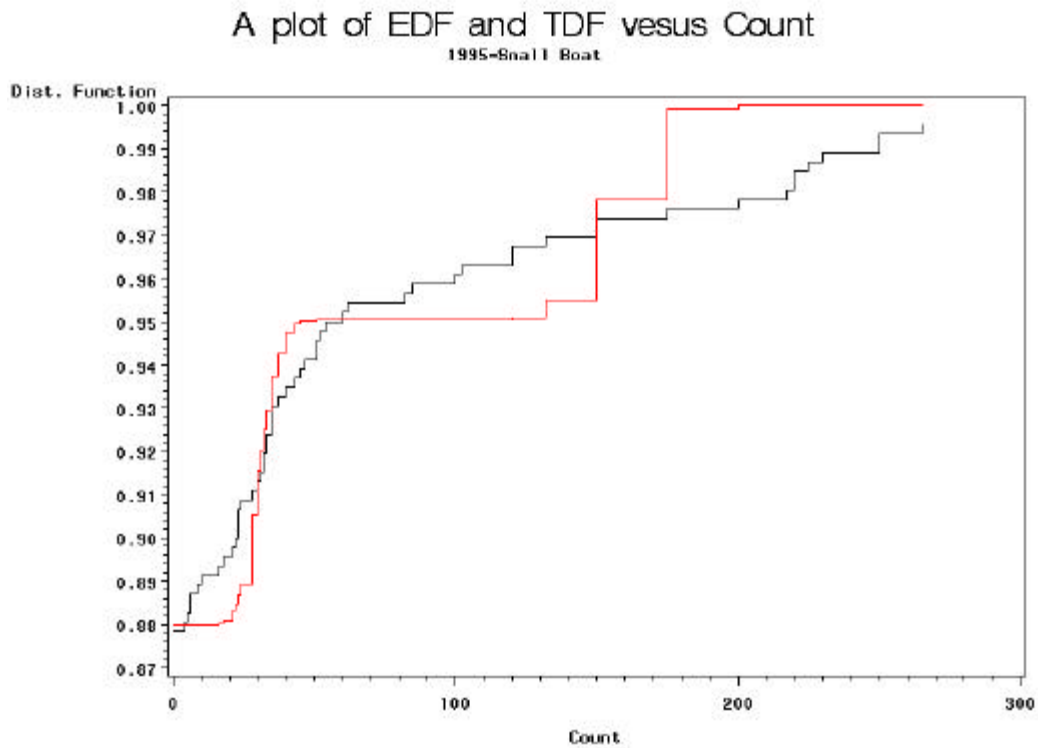

Figure G1. Plot of Empirical Distribution Function (EDF) and Theoretical Distribution Function (TDF) against number of Interior Least Tern for 1995 small boat surveys.

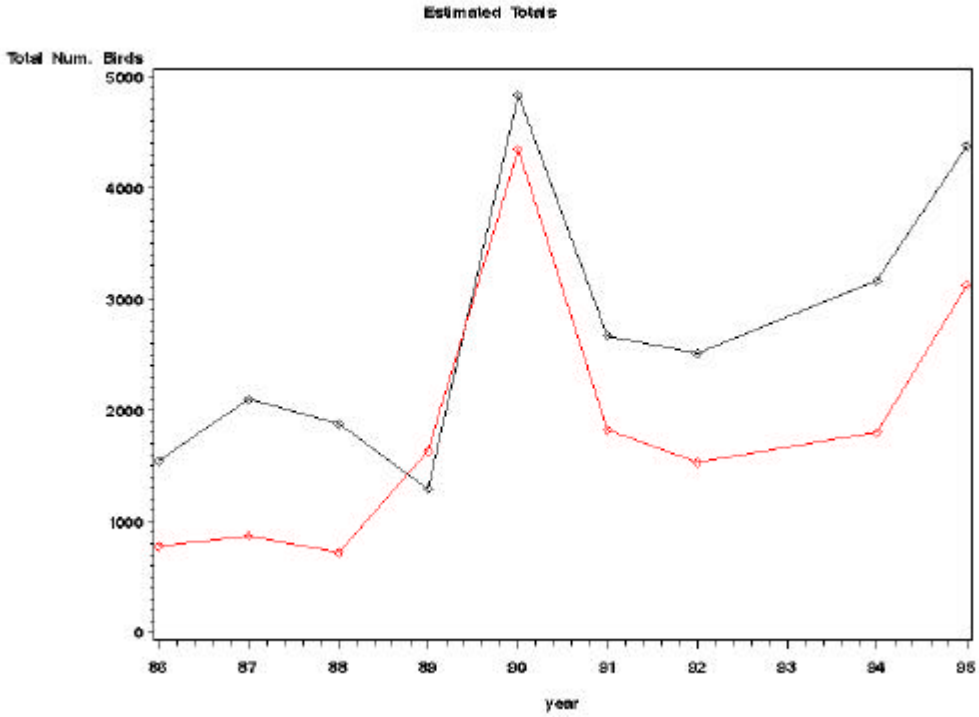

Figure G2. Total number of Interior Least Terns estimated from the Poisson mixture model for Aerial 1 and Small Boat methods from 1986 to 1995.